## PATENT SAFETY BUFFER.

A paper was read "*On an improved patent Safety Buffer.*" By Mr. CHESSHIRE.

Mr. BUCKLE, in introducing Mr. Chesshire's invention to the notice of the meeting, took occasion to express his satisfaction with the principle of the machine, which, with the spiral break of the worthy president, would, be the means of saving many lives on railways. In a former notice of the proceedings of the Institution, we have briefly described the principle of the invention. [See *Journal*, June 1847, p. 190.] It is proposed that each railway carriage should be supplied with a strong moveable rod of iron, solid or otherwise, as might be deemed advisable, supported in the centre of the under framework by bearing sockets. This rod is merely to have an "endway" motion, and is to have a head at each end, similar to the present side buffers, although it is not intended that these heads should act against each other, except in case of collision. When the carriages are screwed up into their ordinary travelling state, there will be a space between the safety buffers of some few inches, which would permit the independent action of the side buffers. This safety buffer would be placed in the "van" at the end of the train, and also in the tender in front—so that it cannot have an endway motion, farther than being fixed against strong elliptical springs will admit of, if such springs should be considered advisable. It was shown, by experiments on a small model railway, that the effect of this continuous buffer was exactly that which its inventor claimed for it. A train of carriages supplied with the rods was brought into collision with an ordinary train; and while the former was unhurt, with the exception of the last carriage, which had broken from its couplings, the other was thrown into the utmost confusion. The whole force of the shock, in so far as the former train was concerned, seemed to be conveyed to, and spent on, the last carriage, which the inventor proposes should be filled with goods or luggage.

Considerable discussion followed the reading of the paper and the experiment. The chief objections were—that the absence of all uniformity in the size and make of carriages would, even if the principle was sound, make the invention practically useless. Then, again, the force of the shock of a collision could only be conveyed throughout the length of the buffer and to the last carriage, when the train was on a straight line. If, for example, it was on a curve that the collision took place, the centre carriages, or the one where the bend was greatest, would receive the force of the shock, and the lives of the occupants of the carriage be sacrificed. Mr. M'Connell was the principal supporter of this objection. It was, moreover, argued by Mr. Ramsbottom and others, that the application of the invention would be a practical disadvantage, except in one case—namely, as a strengthener of the bottom of the carriage. By the present side buffers, the force of a shock was distributed over the whole train—the first feeling the greatest amount of force—and thence it sensibly diminished, until the passengers in the centre, or the extremity of the train, scarcely felt it at all. Now, making the shock simultaneous throughout the whole train, as it was proposed to do, would have the same effect on the passengers as if the train had run against a dead wall. They would be thrown into each other's faces in every carriage in the train. Besides, if the train was run into, the engine and tender, and the men upon that, would be sacrificed.

Mr. CHESSHIRE replied, that, with respect to the indisposition of railway companies to go to the trouble and expense of applying the invention, he thought that the lives of the public was the first great consideration; and no expense and no trouble should be allowed to operate against any invention that promised to reduce the number of casualties. As for the principle of the invention, he was convinced that it was perfectly sound. Accidents seldom took place in curves; there the enginemen were always on the look out. The force of a collision must be spent somewhere; and he could not understand how it could be an objection to his invention, that he carried it off from the carriages where damage to life would be done, and concentrated it where nothing of the sort was to be apprehended. He was convinced that, if the Institution would recommend some of the railway companies to adopt the invention, it would be found to act most beneficially.

After some further remarks by Mr. Wright, Mr. Peacock, Mr. Crampton, Mr. Cowper, Mr. Fothergill, and others, Mr. M'Connell recommended that the consideration of the subject should be handed over to the council, who would discuss the merits of the invention with Mr. Chesshire, which was agreed to.

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## BANKS'S PATENT STEEL TYRES.

Mr. FOTHERGILL read the following paper:—"*The statement of facts relative to* Mr. THOMAS BANKS'S *Patent Plan of Steeling the Tyres of Railway Wheels, is the result of nearly Five Years' Trial, and shows the Cost and Durability of Staffordshire Tyres, Steeled on his Plan, as compared with Low Moor Tyres.*"

The present cost of Low Moor tyres, for 3-feet wheels, will be—

| | £ | s. | d. |
|---|---|---|---|
| Four tyres of 3 cwt. each—12 cwt., at 22s. .. | 13 | 4 | 0 |
| Putting on the tyres ready for work .. .. | 8 | 0 | 0 |
| Twice turning up, after wearing hollow .. | 1 | 0 | 0 |
| Total cost .. .. | £22 | 4 | 0 |

Suppose these tyres to run 50,000 miles on an average—that is 50,000 miles at a cost of 22*l.* 4*s.*—the present cost of Staffordshire tyres will be—

| | £ | s. | d. |
|---|---|---|---|
| Four tyres of 3 cwt. each—12 cwt., at 12s. .. | £7 | 4 | 0 |
| Putting on the tyres ready for work .. .. | 8 | 0 | 0 |
| Steel for steeling one set—1½ cwt., at 42s. .. | 3 | 3 | 0 |
| Man's wages, for turning grooves in the wheels .. | 0 | 10 | 0 |
| Smith's wages, for inserting the steel .. .. | 0 | 10 | 0 |
| Man's wages, for turning up after steeling .. | 0 | 10 | 0 |
| Men's wages, for drilling and rivetting .. | 0 | 7 | 6 |
| Total cost .. .. | £20 | 4 | 6 |

These tyres are proved to run before steeling 18,000 miles, and after steeling 100,000 miles—making a total work of 118,000 miles, at a cost of 20*l.* 4*s.* 6*d.* Now, subtracting 50,000 miles—the work of Low Moor tyres—from 118,000—the work of Staffordshire tyres steeled—we have 68,000 miles which the latter will run more than the former, and at a cost of 39*s.* 6*d.* per set less. From the above statement, we see the cost of Low Moor tyres, per 1,000 miles, is 8*s.* 10½*d.*; whilst the cost of Staffordshire tyres, steeled, is only 3*s.* 5½*d.* per 1,000 miles. The truth of this statement is proved by a test of nearly five years' trial, on those lines on which the plan has been most used. We are aware that railways did not all wear out the tyres alike; but on those lines where the iron tyres will run more than stated above, the steeled tyres will run more in proportion, and the plan is attended with no danger whatever.

*Note.*—The above statement shows only the advantage of steeling the tyres once, but we have steeled many a second time, after they have run the above distance. The same tyres may be steeled a second time at a cost of 5*l.* per set, when they will run 100,000 miles more—making a total of 218,000, at a cost of 25*l.* 4*s.* 6*d.*, or 2*s.* 4*d.* per 1,000 miles. The advantage of steeling a second time is secured by taking the tyres in time, while they have the requisite strength for steeling the first time. The general objection against the plan is, that there will be a deal of trouble to carry it out; but this objection, if properly examined, will be found to be without foundation. When the wheels want turning up, they must be taken from under the carriage, or wagon; and, when taken from under, the cutting of the grooves in the tyres for the steel will not cost more than 5*s.* per pair in men's wages; and, when the grooves are turned, one smith and three strikes will insert steel segments with 10 pairs of 3-feet wheels in one day of 10 hours; after which, turning up the steeled wheels will take very little more time than turning up without steeling, which proves that the trouble will not be so great as some people imagine, and nothing, when the durability and saving which is effected is considered, by the tyres being steeled on this plan.

The paper was accompanied by a letter from Mr. Jenkins, of the Manchester and Leeds Railway, highly commendatory of the steel tyres.

Mr. PEACOCK remarked, that he had tried the wheels steeled by Mr. Banks's process, and the result was, that whereas he was formerly obliged to repair the wheels of the tenders every four months, those with steel tyres did not require repair oftener than once in 12 months. He had not fully tested their wearing qualities, but he had no doubt that they would be found to be most economical as well as useful.—Several other of the members spoke in high terms of the value of this patent.

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## ROYAL SCOTTISH SOCIETY OF ARTS.

*April* 24.—JOHN BURN MURDOCH, Esq., F.R.S.E., V.P., in the Chair.

The following communications were read:—

1. "*On the value of Gases from different Coals, and the price of Light in different places; also a new mode of estimating the Consumption of Gases, &c., and of estimating Illuminating Power.*" By ANDREW FYFE, M.D., F.R.S.E.

The first part of this paper referred to the illuminating power and durability of gases obtained from English caking coal, from English parrot coal, and from Scottish parrot coal, with which gases the towns in England and Scotland are supplied, and consequently to the value of these gases for affording light. Taking the illuminating power, and the durability, and consequently also the values of the gas from English caking coal, with which Newcastle and many other towns in England are supplied, as the unit of comparison, Dr. Fyfe stated, that he found the illuminating power of the gas from the English parrot coal, such as that from Yorkshire and Lancashire, to be, on an average of numerous trials, 1·73, the durability to be 1·12, and hence the value, bulk for bulk, as 1·85. The value of gas from the different kinds of Scottish parrot coal varies considerably, according to the place from which the coal is obtained; but, as in the larger towns in Scotland, a mixture of coals of different quality is employed, the gas in these towns is generally very nearly of the same quality. Taking the average of all the trials made at Edinburgh, Glasgow, Greenock, Dundee, and Aberdeen, the illuminating power was found to be 3·23, the durability, 1·58; thus making the value very nearly 5, compared with the English caking coal gas as 1, and 2·7 to the English parrot coal gas as 1; in other words, to light an apartment to the same extent, and for the same time, by similar methods of consumption, the quantity of gas from Scottish parrot coal required, being as 1, the quantity of gas from English parrot coal would be more than double, and that from English caking coal would be five times as great. Dr. Fyfe

then alluded to the value of these different kinds of coal for affording gas, and consequently for affording light by the combustion of their gases. In ascertaining this, the quantity of gas given off from the coals is taken into account, along with the value of the gases themselves for affording light. In this way he has fixed the value of the coals as follows:—English caking coal being 1; that of the English parrot coal is on an average 2·3; and that of the mixture of Scottish parrot coal, as used in different towns, as 6.

In the second part of the paper, Dr. Fyfe alluded to the methods of finding the value of coal gas, for the purpose of illumination, and more particularly to a new mode of determining the durability; in other words, the time required for consuming a certain volume of gas, and consequently the consumpt in given times, and by means of which, also, the specific gravity of the gas could be ascertained. From numerous experiments which he had performed, he had come to the conclusion, that when coal gases are burned from the same burner, with the same height of flame, the consumpt is as the square roots of the pressure necessary to keep up the combustion, at the length of flame fixed on; and that, consequently, the time required for the consumpt of equal volumes is inversely as the square roots of the pressure He had also come to the conclusion, that the durability, in other words the time required for the consumpt, depends on the specific gravity, and that the same law is applicable; consequently, the specific gravity being known, the consumpt can be determined; as the consumpt being determined, by the pressure, the specific gravity can be ascertained, the rule being, the specific gravity is inversely as the square roots of the pressures, necessary to keep the gases burning, from similar burners, at the same height of flame. Dr. Fyfe stated, that he had put these different rules to the test of experiment, with gases which he had prepared from different coals, and also with the gases found in different towns, and he exhibited numerous tables, showing the very close correspondence between the results obtained experimentally, and by calculation. He then exhibited an instrument by which the durability and specific gravity, could by the rates stated, be determined. It consists of a jet burner, of the 40th of an inch in diameter, to which is adapted a scale for measuring the height of flame, and a pressure gauge for ascertaining the pressure under which the gas is burning, at the length of flame fixed on. In this pressure gauge is fitted a graduated scale, with a burner, by which the pressure can be read off, to $\frac{1}{100}$th of an inch. Along with this a table was given, showing the consumpt of gases in a given time—the time required for the consumpt of equal quantities, and the specific gravities, according to the pressures indicated by the gauge. In the table the pressures ranged from $\frac{60}{100}$ths to $\frac{800}{100}$ths of an inch, which embraces all the pressures likely to occur with the jet burner stated.

Dr Fyfe, in conclusion, alluded to a photometer, which, so far as he was aware, is not noticed in any publication, and which, he believed, was the invention of Professor Bunsen. It consists of a paper screen besmeared with a solution of spermaceti in oil of naphtha, excepting at a part around the centre. A candle placed behind this transmits light in such way as to make the part uncovered easily observed, but when another light is placed in front of the screen, at a certain distance, according to the intensity of the light the spot disappears, and the paper becomes uniformly of the same appearance. In using other lights, the distance at which the uniformity on the surface of the screen is occasioned, depends on the intensity of the light; and thus, according to the usual law, the illuminating power of different lights is determined by the square of the distances at which they are situated from the screen. Dr. Fyfe stated that he had put this method to the test of experiment, and found it extremely accurate, and much more easily managed than the shadow test. He exhibited the screen in connection with the pressure gauge burners, already described, by the use of which, the illuminating power, the durability, and the specific gravity of coal gases are very easily and quickly determined; and hence the value of an instrument of this kind to those travelling from place to place, with the view of ascertaining the value of coal gas in different towns; and of ascertaining the value of different kinds of coal for affording gas, and consequently for affording light by the combustion of their gases.

2. "*On the Composite Ellipse, as an element in the useful and ornamental arts,—being the second of a series of short papers upon the Harmony of Form.*" By Mr. D. R. Hay.

Mr. Hay said that the paper and illustrations he now brought before the Society would show that the composite ellipse, as he described and arranged it, was an important element in the useful and ornamental arts. He then explained the relation which his composite ellipse bore to the circle, and to the regular ellipse; also his mode of describing it, with an analysis of its composition. For this purpose he exhibited six large diagrams. He then went on to show that its beauty consisted in the variety of its parts being in an equal ratio to their uniformity; and that it was to regulate and classify the various developments of this variety, that he had in his work on "First Principles of Symmetrical Beauty," classified a series of forty-two of those figures, by an application of the laws of numerical ratio.

Mr. Hay then stated that he had brought the same subject before the Society about three years ago, as calculated to improve the practice of various arts; and that as it bore upon the humblest productions of the potter's art, the mechanic and the cottager might have, without additional cost, household utensils of forms as beautiful as the finest specimens of the bantique.

Mr. Hay then observed that it had lately been stated in the Society that his composite ellipse had not novelty to recommend it, but had long been familiar to every one who had given any attention to the subject; and that Nicholson's "Dictionary of Architecture" had been referred to in corroboration of this statement. Mr. Hay, however, stated that neither the composite ellipse, his method of describing it, nor its application to the drawing of vases, was published in Nicholson's "Dictionary of Architecture," or elsewhere, before he exhibited them to the Society, as just stated.

3. "*Description of a new Ball Stop-cock for Water Cisterns, and of a Nose-cock for Casks or Vats.*" By Mr. Daniel Erskine.

The new ball-cock consists of two flat surfaces ground air-tight, having port holes for the water when in certain positions, and furnished with a spiral spring, that keeps the surfaces in contact. This spring is screwed down to the pressure of the water that it is fitted for, and as the water tends to lift it off the face, this gives it slight friction on either side, and it is not so liable to get fixed as the present ball-cocks are. The same kind will be of great advantage for gas-works, distilleries, and breweries, where large nose-cocks are required, and will be much less expensive.

4. "*Description of a Model of a Stop-cock for Corrosive Fluids.*" By Mr. James Robb.

This stop-cock is intended to obviate the tendency to stick fast, which the plugs of all the common kind have, especially when the fluids are of a corrosive or drying nature, such as common gas; and as it will have no tendency to leak, it may be employed with advantage in oil, beer, or water casks. Its principal peculiarity consists in using vulcanised india-rubber tubing, connected with the pipe by screw couplings, and compressed by means of a screw, or otherwise, to any extent required, by which the flow of gas, or other fluid, may be regulated at pleasure.

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## INSTITUTION OF CIVIL ENGINEERS.

*April* 11.*—Joshua Field, Esq., President, in the Chair.

The paper read was the second part of a communication made in the year 1841, descriptive of the "*Bann Reservoirs, County Down, Ireland.*" By I. F. Bateman, M.I.C.E.

The first part, of which a short abstract was read, gave the object of the construction of these reservoirs, which were undertaken with the view of regulating the quantity of water in the River Bann, and more effectually supplying water-power to the flourishing and increasing establishments on its banks; this river is, from the bare and naked character of the Mourne mountains, among which it rises, naturally liable to the greatest irregularity in its volume; devastating floods frequently pour down the channel, where, a few hours previously, there was not sufficient water for agricultural purposes. Greatly injurious as this must have been to the agriculturist, it was infinitely more so to the mill-owners, who depended entirely on water-power for their manufactories. Mr. Fairbairn was consulted on the subject; he examined the locality, and advised the formation of reservoirs; the author was then appointed the engineer, and, acting in some degree upon the suggestions of his predecessor, whom he continued to consult, the works were undertaken which are described in the present paper. The peculiarities in the Act of Parliament, granted in 1836, constituting the proprietors of the mills a joint-stock company, for the formation of the Bann reservoirs, are detailed. The works were originally intended to have been more extensive than have been really executed. The reservoir at Lough Island Reavy is alone described; the ground in that spot was admirably adapted for that work, being the bottom of a basin, which was bounded on all sides by rugged hills of granite; in the centre of the basin was a small lake, at the bottom of which was discovered a bed, several feet in thickness, of fossil confervæ, similar to those discovered by Professor Silliman, at Massachusetts, North America. This interesting geological fact was first noticed by Dr. Hunter, of Bryansford; the confervæ appeared like an impalpable powder, but when viewed through a powerful microscope, they were found to be regular parallelograms, many of them covered with striæ. They are described by naturalists as the fossil skeletons of minute vegetables. The situation fixed upon for the reservoir rendered necessary the construction of four embankments, between the hills, so as to raise the water to a height of 35 feet above the summer level of the lake. The particulars are also given of a series of observations with rain gauges, continued for two years, for the purpose of furnishing data for computing the extent of reservoir which would be necessary to insure a supply of water throughout the year. The continuation described the subsequent works, which consisted of the Corbet Lough reservoir, which was designed as an auxiliary pond, to receive the flood-waters of the lower part of the river, and to retain the night water, to be discharged again during the day, immediately above the more extensive mills on the river. A water-course, of considerable dimensions, was constructed to effect this, and an embankment was thrown across the narrow outlet of the lake, the water being admitted through self-acting flood-gates, which closed as soon as the lowering of the river created a current in the contrary direction. The details of the construction of all these works were given; and it was shown, by calculations based upon actual experiment, and observation of the quantity of water received, stored, and delivered from the reservoirs, that their construction had increased the value of the mill-power of the River Bann full five-

* This paper was accidentally omitted in the report of last month's proceedings.

fold, at a comparatively very insignificant cost, as the actual expenditure for the works at Corbet Lough did not exceed 3,300*l.*—the closest economy, consistent with the efficiency and durability of the work, being rigidly kept in view, and the utmost attention being exercised by the resident engineer, Mr. W. L. Stoney.

*May* 9.—"*Observations on the Causes that are in constant Operation, tending to alter the Outline of the Coasts of Great Britain, to affect the Entrances of Rivers and Harbours, and to form Shoals and Deeps in the Bed of the Sea.*" By Mr. J. T. Harrison, M.I.C.E.

After noticing the gradual deterioration which the harbours of Great Britain are undergoing, the paper gave as the causes of these effects, the action of fresh water, of the tidal wave—the wind waves, and springs, and atmospheric changes, dwelling principally upon the tidal and wind waves. Professor Airy's and Mr. Scott Russell's views on the positive wave of translation (first order), and the oscillating wave (second order), were examined; the peculiarity of the former being, that the motion of the whole mass of the water was in the same direction as that of the wave itself; whilst, in the latter, the motion of the water was alternately opposed to, and in the direction of, the wave. The tidal wave was considered as a purely oscillating wave in the open sea, changing its character as it passed into shallow water. It was supposed that a wave of the first order was generated whenever the water, heaped up by a projecting headland, passed and made its escape into the adjoining water, at a lower level, and that it carried with it gravel and shingle into mid-channel. The regularity of the bottom of the English Channel, and the material of which it is composed, were instanced, to prove that the bottom was now in progress of formation from the aqueous action of this deposition of matter. The effects of the tidal wave along the coasts at Poole, and in the Isle of Wight, were given, to show that such a wave of translation was generated and crossed the Channel, from the Department de la Manche. The results of a series of experiments upon the action of waves on transportable materials showed that certain definite forms were assumed by sand or shingle, under given circumstances—for instance, that the depth of the end of the foreshore below the water depended upon the size and character of the wave acting upon it. It was urged that the end of such a foreshore was to be found at 90 or 100 fathoms under water, stretching from Ushant to the south-west coast of Ireland, and that the tidal wave, in its progress up the channel, drew down to the mouth the material thrown into it by the waves of translation from the headlands. The accumulative action was seen in the carriage of sand through the Straits of Dover to be deposited on the sand banks of the North Sea.

Referring to Mr. Palmer's paper "*On Shingle Beaches*," the destructive, accumulative, and progressive actions of the wind waves were considered. The cases most favourable for the display of the effective actions of each were adduced. The influence of tides by varying the height of the water, and that of an on-shore wind in facilitating the destructive action, by retaining the water at a higher level, were pointed out. A flat foreshore, was shown to prevent, in a great degree, the destructive action; whilst, on the other hand, deep water, whether from a strong in-shore tidal current, or from other causes, had a contrary effect, facilitating encroachments on the coast. The progressive action was shown to depend principally upon the angle at which the waves strike the beach. The general question of the travelling of shingle, and of its ultimate destination, was considered at great length—instancing particularly the accumulation of shingle at the Chesil Bank and Dungeness. The state of the Great Western Bay, between the Start Point and Portland, was examined, and arguments were offered to show that it had been formed, in a great measure, by the encroachment of the sea. The process of this encroachment, and the alteration in the mouths of the estuaries falling into the bay, were analysed; and extracts were given from Sir H. De la Beche's work on the geology of Devon and Cornwall, to prove that this process was still in operation. The summary of the arguments in the papers was, that the observed changes in our coasts and the mouths of the rivers were the result of the combined action of the wind wave, and of the tidal wave; and the attention of engineers was particularly directed to these actions in different localities, in order that, by presenting to the Institution the result of their observations, an invaluable collection of recorded facts might be assembled, which would be of great benefit to the profession, and to the scientific world.

*May* 16.—This evening was occupied with a discussion on Mr. Gooch's paper "*On the Resistance to Railway trains at different Velocities*," read at the meeting on April 18.—[See *Journal, ante* p. 155.]

The principal speakers were Messrs. Brunel, Gooch, Bidder, Locke, Harding and Russell, and their arguments were necessarily so complicated by calculations as to render it difficult to convey, within reasonable limits, even an outline of the discussion. It was contended on one side that the subject had been so treated in the paper as to make it almost a question of the comparative gauges; that the experiments upon which the arguments were founded could not be received as applicable to railways in general, inasmuch as it was presumed from the statements that the portion of the line was selected as being in the best working condition; that the engine and the carriages were also picked as being in the best order; and that therefore the results were due to these peculiar circumstances, and not to the ordinary working state of the line; that the amount of resistance per ton was understated by Mr. Gooch on these accounts, and that the rate of resistances arrived at by the committee of the British Association, by projecting trains of carriages down inclined planes, was nearer the truth than the expression of resistance arrived at with the locomotive and the dynamometer; that the tables were partly made up from the actual results of the experiments and by using Mr. Harding's formulæ, which had been repudiated in other cases as incorrect; that the greater weight of the trains in the late experiments, as compared with those of the British Association, &c., reduced the value of the deductions; that the atmospheric railway could alone give the resistance due to the frontage, which was not given when a locomotive was used, as it covered a portion of the carriage frontage, and the dynamometer being behind the engine, the resistance of the train of carriages alone could be arrived at; and that the valuation of the pressure of the wind upon the train at various angles was not satisfactory. Such was the general tenor of the arguments; and on the other side it was urged that Mr. Gooch had endeavoured, as much as possible, to avoid introducing, in any degree, the question of the gauges, and to give the actual results of the experiments, in order that any persons examining them might draw his own conclusions; that the portion of the line on which Mr. Gooch's experiments were tried was not selected for its good condition; that it was fixed upon by Mr. Brunel himself only the night previously to the experiments, and was not that part which had been originally intended to be used; that the engine and carriages were such as could be spared from the working stock and were not picked—in fact, that they were not the best of their class; that therefore the results were not due to peculiar circumstances, but were those of the average working of the line; but that even had the line, engine, and carriages being selected, engineers would, from the results, have been able to make allowances for other cases, and that the value of the experiments would not have been diminished; that it was believed that in descending Wootton Basset incline by gravity, without the aid of an engine, a greater velocity had been attained than the maximum recorded in the experiments of the British Association; that the tables were divided into columns, distinctly showing what resulted from experiment and what from the use of formulæ; that it was impossible, with engines of the ordinary weight, as now constructed, with an ordinary train, to limit the experiments to such small weights as had been formerly used; that in all cases the surface of the locomotive was allowed for in calculating the frontage resistance; that it was expressly stated in the paper that the apparatus for the wind gauge was not so satisfactory as could have been desired, and therefore its results were kept separate in the tables; that Mr. Gooch had not intended to cast any reflections upon the former experimentalists, but merely to point out the errors into which he thought they had fallen, and to induce, by his experiments, others which should fix more certainly the amount of resistance; this, it was still contended, was less than had been formerly stated, and although other experiments would be necessary to set the question completely at rest, it was unanimously agreed that Mr. Gooch's experiments and paper were very valuable contributions, and it was hoped he would continue his observations on this most interesting subject.

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## ROYAL INSTITUTE OF BRITISH ARCHITECTS.

On the 8th ult., a special meeting of the Institute was held, to take into consideration a memorial submitted to the council in April, 1847, urging the formation by the Institute, of a benevolent fund for the less fortunate members of the profession, signed by thirty-four architects. Mr. Bellamy, Vice-President, laid before the meeting a summary of the proceedings which had been taken upon it, the result of which was, that the council had adopted the report of a joint committee (part memorialists, part members of council), advising the formation of such a fund, and recommended it to the consideration of the members at large. The rule of the Artists' Benevolent Fund, that recipients must be authors of "works known and esteemed by the public," would shut out many deserving members of the profession, and those connected with it. Communication had been opened with the officers of that fund, by some who thought that the desired end might be better attained by an arrangement with them than by a fresh fund. A long discussion followed as to the mode of carrying out the views of the memorialists, and as to the necessity for the fund. An opinion was generally expressed, that if raised at all, it was quite unnecessary to give the administration of it to another society. Ultimately, on the motion of Mr. Angell, a resolution was passed, declaring the importance of establishing such a fund, and appointing a committee of nine, to consider in what way it could best be effected, and to report hereafter.

*May* 15.—Mr. J. W. Papworth read a paper in illustration of some drawings of Prœneste, ancient and modern; and Mr. J. Thomson read some observations on the ancient village church of Leigh-de-la-Mere, Wilts.

*Mr. Angell's Conversazione.*—On the 25th a conversazione was given by Mr. Angell, Vice-President of the Institute of British Architects, at his residence in Gower-street, which was attended by all the leading members of the architectural profession, the Marquis of Northampton, and the heads of the scientific world. Many works of art were exhibited, and much gratification was expressed at the valuable example set by Mr. Angell to his colleagues, in affording such a *réunion* to the professors of architecture.

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## ON FLAME AND GASES.

Professor Faraday lately read a paper at the Royal Institution, "*On the Diamagnetic Condition of Flame and Gases.*"—Mr. Faraday having briefly recapitulated the chief subjects of his recent research into the magnetic condition of matter, proceeded to state a still more recent extension of these researches made by Prof. Bancalari at Venice. Prof. Bancalari has shown that flame, when placed between the poles of a powerful magnet, becomes *diamagnetic* (*i. e.* spreads out in the plane which is perpendicular to the line joining the poles of the magnet). Prof. Faraday's object was—first, to remove certain misapprehensions of his own published opinions in regard to this phenomenon; and, secondly, to give a philosophical account of it. Referring to his "Experimental Researches," in the *Philosophical Transactions*, read in 1845 (pars. 2423, 2433, 2435), he showed that he had never asserted, as had been imagined, that the gases were *not* subject to magnetic action; but merely that his experiments had not then established that they were affected by that force. The causes of this magnetic influence were then considered. Flame was dissected, and its complicated nature—consisting of solid matter, of a surrounding film of heated air, and of gaseous products of combustion—was experimentally demonstrated. The following experiments were then exhibited to prove (*a*) that *hot air is diamagnetic with reference to cold air*—(*b*) that *carbonic acid gas, a product of combustion, is diamagnetic*—(*c*) that *carbon, which is liberated during combustion, and imparts luminosity to flame, is also diamagnetic.*

(*a*) *Hot air is diamagnetic with reference to cold air.* The hot air rising from a glowing spiral of platina wire, placed between the poles of a powerful electro-magnet, was proved to be bent aside by the fact of its inflaming a piece of phosphorus in the equatorial plane on either side of the red-hot platinum while the magnet was active, and also by its not firing the phosphorus (as would happen in the ordinary condition of things) when this substance was placed immediately above the heated wire.

(*b*) *Carbonic acid gas is diamagnetic.* This was proved by a jet of that gas being made to diverge from the perpendicular downward current, which its gravity would cause it to take, into a flask of limewater (which it rendered turbid) placed in the equatorial plane.

(*c*) *Solid carbon is diamagnetic.* It was shown that the smoke of a taper, when placed beneath the axial line, divided itself, as flame was made to divide, into two streams in the equatorial plane, each on either side of this axial line.

The singular condition of oxygen gas, in being far less diamagnetic than the other gases, and therefore appearing as if magnetic, like iron, when surrounded by other gases or air, was demonstrated by its carrying a cloud of muriate of ammonia (itself diamagnetic) to the poles of the magnet, around which it seemed to gyrate in vortices.

Mr. Faraday concluded by noticing the apparently exceptional case of flame penetrating the pierced poles of a magnet, and coming through them in an *axial* line. He showed that in this case the maximum of force was not in this line, but in the circle of lines forming the edges of the hollow cylinder drilled through the poles. Therefore—inasmuch as the force in the vacant space was feebler than the force at its solid circumference—flame, which always goes away from the spot where the force is strongest to the spot where it is weakest, penetrated the hollow axis of the cylinder.

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## PROCESSES FOR UNITING METALS AND METALLIC ALLOYS.

At a recent meeting of the Berlin Academy of Sciences, M. PULBRICH, founder, of Hamburgh, communicated an account of his processes for firmly uniting metals or metallic alloys, which possess different properties and values, such, for example, as bar-iron with cast-iron, gun-metal with cast-iron, and thus to obtain pieces of mixed metal suitable to make clasps, girders, panel squares, railway bearings, wheels, axle-trees, and other parts made use of in machinery and in building, possessing the weight and the cohesion required, but much harder and more resistent in certain parts than inothers. The following is the process adopted, as described by the inventor:—

"*To Unite Bar-iron to Cast-iron.*—In order to unite bar-iron to cast-iron—to make, for instance a bar of rectangular girder, of which one-fourth the thickness shall consist of bar-iron, and the three other parts of cast-iron, or rather in the combination of one volume of these metals in any proportions, I proceed as follows:—I take a bar of iron, of the required thickness, and I plunge it into a cleaning bath composed of nitric acid or any other acid diluted with water. I then take it out of the cleaning bath, expose it to a red heat in a furnace, and plunge it again into the cleaning bath; by means of these operations, I get rid of all the oxide from the surface of the metal. To remove from this bar any acid which might remain, I wash it with any alkaline solution (for instance, sal ammoniac), and I immediately plunge it into a bath of melted tin, where I allow it to remain until it has become well tinned over its whole surface. This done, I apply to the tinned iron at the side where it is to be united with the cast-iron, an alloy or solder composed of copper and tin, in the proportions of five parts of copper, and 95 of tin. The bar of iron thus prepared is then introduced to the bottom of a mould of the form and dimensions corresponding to the bar which it is wished to be produced, and it is kept down by iron bolts or nails, which have previously been well tinned; the cast-iron is then poured in a liquid state on the bar of iron, until the mould is filled. In this state, a fusion takes place at the surface of the iron in contact with the liquid cast metal, and under the influence of the alloy of solder of copper or tin interposed, the two pieces of bar-iron and cast-iron unite so firmly the one to the other, that it is almost impossible to separate them.

"*To Unite Steel with Cast-iron.*—Follow exactly the same process as above described.

"*To Unite Copper, Bronze, Gun-Metal, or Brass, with Cast Iron.*—These alloys, as well as all those of copper, can be united by exactly similar means to those above described; except that instead of clearing the surfaces of the alloys by means of acid and alkaline solutions as above mentioned, the surfaces should be filed, and the union with the cast-iron effected at the lowest temperature possible, in order that the bar of alloy might not be melted.

"The proportion indicated above for the composition of the alloy or solder is that which appears the most suitable, where the pieces of metal to be united are of moderate dimensions; but when they exceed moderate dimensions, it will be better to increase the proportion of copper employed.

"In the examples given above, it is supposed that the different metals were united together on one side only; but one of these metals may be united at two sides, or at two opposite or adjacent faces, to the other metals, or even covered throughout its entire surface. Further, the pieces of metal may have a curvilinear, angular, or any other form, and the mmanner of oulding may be varied according to the rules which practice has long since furnished in foundries."

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## THE EFFECTS OF ZINC ON IRON.

A letter from Mr. James Nasmyth, of Bridgewater Foundry, Patricroft near Manchester, to the *Mining Journal*, communicates the results of some experiments recently made at the desire of the Lords of the Admiralty, with a view to determine whether old iron that had been galvanised, or coated with zinc, was rendered unfit for being again worked-up. The results of these experiments seem to prove that the quality of the iron is improved instead of being deteriorated by the zinc combined with it. The following is Mr. Nasmyth's report of the experiments:—

"A piece of galvanised iron-wire rope was welded up into a bar, and put to the most severe test. In the first place it was found, that although the iron-wire was quite covered with metallic zinc, which, although partially driven off in the process of welding, yet, so far from the presence of the metal, or its oxide, presenting any impediment to the welding of the iron (as in the case of lead), the iron-wire welded with remarkable ease; and the result was, a bar of remarkably tough, silvery-grained iron, which stood punching, splitting, twisting, and bending, in a manner such as to show, that the iron was not only excellent, but, to all appearance, actually improved in quality in a very important degree.

"Encouraged by such a result, a still further, and even more severe, trial was made—viz.: by welding up a pile of clippings of galvanized iron-plates, or sheet-iron, covered with zinc, as in the former experiments. The presence of the zinc appeared to offer no impediment to the welding, and the result was, a bloom or bar of iron—the fractnre of which presented a most remarkable and beautiful silvery grain—as good, if not superior, in aspect to the finest samples of 'Low Moor' or 'Bowling' iron. Bloom of this iron were rolled out in rods, and tested in the cable-proving machine, and the result indicated from 5 to 10 per cent. higher strength than the best samples of wrought-iron—thus establishing the fact, that, so far from the presence of zinc being destructive to the strength and tenacity of wrought-iron, the contrary is the case.

"I may mention, that bars of iron were heated to a welding heat, prepared by Scarf for sheathing, in the usual manner; and, on drawing them from the fire, for being welded, a handful of zinc filings was thrown on the welding hot surface, and the welding proceeded with. In this severe test no apparent impediment to the process resulted; the iron welded as well as if no zinc had been present."

Mr. Nasmyth infers from these experiments, that some improvement might be made in the manufacture of iron, by the introduction of metallic zinc in the puddling furnace. In corroboration of this opinion, he adduces the fact that the strongest cast-iron made in Belgium, and selected for the casting of guns, is made from an iron ore in which the ore of zinc forms a considerable portion.

Mr. Leighton, of Cwmammon, following up the suggestion of Mr. Nasmyth, has communicated other applications of zinc to iron, which he had devised for the purpose of bringing anthracite coal more into use. His object was the preparation of pure oxide of zinc to be used as paint, for iron-work more especially, for making joints, &c., in lieu of white-lead. "If," he observes, "people could be once induced to make a trial of anthracite coal, worked by a blast, for several manufacturing operations, the value of this peculiar fuel would be established. It only requires a beginning; it is quite possible to treat the sulphuret of zinc—a very abundant ore, known as blende, or black jack—so that pure oxide of zinc

and sulphuric acid should be prepared by the same operation. This would be a very profitable business, and create a consumption for a considerable quantity of the ore; but at the present price of the metal, it would even pay handsomely to prepare oxide of zinc from spelter. Say, in round numbers, 4 cwt. of spelter, worth £2 16s., would yield 5 cwt. of oxide of zinc, which, at the price of dry white-lead, would be worth £6; the cost of labour and fuel being trivial, there would be a profit of something like cent. per cent."

## SUPPLY OF WATER FROM THE NEW RED SANDSTONE.

A paper "*On the Supply of the Town of Liverpool with Water from Shafts sunk in the New Red Sandstone,*" was lately read at the Polytechnic Institution, Colquitt-street.—After some observations, as to the importance of a plentiful supply of pure water, the lecturer remarked that the original source of all water found in the earth is the rain which falls from the clouds. Though the fall of rain at Liverpool was only about 36 inches per annum, in the interior and hilly parts of the country it was far greater; for instance, in 1845, there fell at Seathwaite 151 inches; Grasmere, 121; Buttermere, 87; Keswick, 62; Whitehaven, 49; Cockermouth, 47; and at Manchester, the fall averages about 41 inches. He had examined various springs in the new red sandstone, and had never found any above the mean temperature of the climate; and concluded, therefore, that those in the new red sandstone were entirely supplied from the rain which falls from the clouds, estimated in that district at 36 inches per annum. Allowing 18 inches for evaporation and vegetation, would leave 18 inches absorbed and stored in the earth every year, giving 392,040 gallons per acre, or 250,905,600 gallons per square mile. He maintained that the strata of the new red sandstone, at a level below the surface of the sea, are naturally, fully, thoroughly, and permanently saturated with water; and that any shaft or excavation sunk to that depth, will always, through lateral percolation, be full of water to that height. He considered the most desiderable mode would be to sink shafts from 1,000 to 2,000 feet deep, which would pierce a stratum highly saturated with water, and which would be filled to within a short distance of the surface. He objected to the plan proposed by some persons to be adopted, that of bringing surface water from a distance, as all such was impregnated with millions of myriads of animalculæ, to the great detriment of public health. In conclusion, he stated as his decided conviction, that the strata of the new red sandstone formation are not yet exhausted of their water, neither do they show any symptoms of exhaustion, neither is it possible to exhaust them, so long as they maintain their present constitution and geological position; so long as they consist of innumerable beds, of variable hardness, and of variable porosity; so long as they are capable of lateral percolation; so long as the hydrostatic pressure of the sea enables them to keep their lower beds at the full point of saturation; so long as their upper beds are greedily absorbant of water; and so long as Nature, in her bountiful beneficence, is annually pouring down upon them more than 500,000,000 gallons of water upon every square mile of their surface.

## THE VENTILATION OF TOWNS.

We have received from a correspondent at Liverpool, a description of a plan, which he has for a long time considered, for effectually securing the ventilation of large towns; and if capable of being carried into practice, it would have the effect of not only ventilating the houses in crowded neighbourhoods, but it would also purify the drains, the exhalations from which are frequently the cause of disease throughout large districts. The communication is too lengthy to be given entire; we shall therefore only extract those portions describing the proposed plan, which may be thus briefly stated. It is proposed that in each town one or more large, high chimneys shall be built, with which all the main-drains shall communicate; and that the fire-places of each house, instead of having chimneys carried through the roof, shall have flues carried below and entering the drains. At the bottom of each of the large ventilating chimneys, fires are to be kept burning for the purpose of causing sufficient draught. This plan, which carries out on an extended scale the mode adopted in ventilating the Houses of Parliament and other large buildings, offers important advantages as a sanitary measure, and ought not therefore to be discarded as impracticable without due consideration. The writer, who is an engineer, affirms that he has tested its practicability, by detailed calculations. We will now let him develope the plan in his own words:—

"It is proposed, that all house and factory chimneys be discontinued; that the smoke and products of combustion, instead of ascending as heretofore, and being discharged at the roof, be made to descend, pass into the house-drains, and through them into the public sewers; the factories having special communication for themselves.

"It is further proposed, that the sewers be arranged to converge and join into larger or main sewers, which would be conducted through the town, to the highest and least-occupied ground in the vicinity, where these mains, culverts, or tunnels, would terminate in chimneys of great height and capacity, placed at suitable distances apart; and in these chimneys, fires would be maintained constantly burning, for the purpose of creating the necessary draught Besides the communications for withdrawing the smoke from the house-fires, the writer proposes to provide orifices in each apartment, connected with the drains, which could be opened and shut by the inmates at pleasure, and there would also be openings at suitable distances along each court, lane, and street, communicating with the sewers. Still more clearly to illustrate his views, suppose we take the case of Liverpool, with the situation of which the writer happens to be acquainted. Let us presume that four or five large chimneys were erected along the brow of the hill which bounds that town to the east,—one to provide for ventilation of the north-end, one for the south-end, and two or three for the middle district; that leading tunnels were driven downwards towards the river, which tunnels would communicate laterally with, and receive the air and smoke from, the street sewers. Then, let us see how this plan would operate:—Suppose a powerful current upwards, was established in the large chimneys, tunnels, and sewers, it follows that—Firstly, the sewers and drains themselves would no longer give forth noxious exhalations. Secondly, by opening the apertures in the streets and courts, we would withdraw the impure air, and produce a constant influx of pure air, which would descend from above. Thirdly, by opening the orifices in the houses and apartments, although they were crowded with inmates, yet the vitiated air would be so rapidly removed, and replaced by that both fresh and pure, that no injurious consequences would ensue. Fourthly, there would be no more smoke or sulphurous vapour to destroy health, and soil everything exposed to its vile influence; the murky clouds which envelope our manufacturing cities would disappear, and give place to clear skies and a pure invigorating atmosphere.

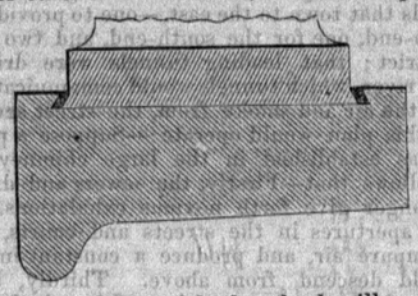
"But it will be said, there would be serious difficulties to contend with in the execution of such a plan: this is granted—but they are far from being insuperable; in proof of which, the writer will now proceed to consider some of them, only avoiding matters of engineering detail. It may be objected that such a scheme would prove costly: it is not denied that it would require the outlay of a large, though by no means extraordinary, sum of money; but can we expect to realise great benefits without proportionate expenditure? If it cost a million to supply such a town as Liverpool with water, why should we grudge a very much smaller sum to supply the same town with air? The one is surely as essential to the well-being of the community as the other; and the writer is prepared to show that a large saving of money would accrue, which is at present expended by the adoption of such a plan, irrespective of the immense benefit to the public on the score of health. There would be no factory chimneys to erect; a great saving in the arrangement for house-fires, which cannot here be detailed; smaller houses and smaller apartments would suffice for any given number of individuals,—consequently, there would be an economy in building arrangements, accompanied by lower rents. The same remark applies to streets, lanes, and courts: look at the enormous sums which would be required to alter and widen them, and by that means improve the ventilation. Then consider the control which would be vested in the authorities over the public health. At present, it is in vain you tell the poor to go dwell in larger houses and more airy situations,—they cannot afford it. It is in vain you tell them not to crowd together in their wretched apartments, or they will suffer from want of ventilation. It is in vain you impress them with the necessity of cleanliness, and of breathing untainted air: the majority disregard it,—how *can* they do otherwise? But with this plan in operation, let us suppose fever to prevail in some court or alley; we have only to give directions to unclose one or two apertures, and pure air *will* flow in, w eeping disease and death away."

*Solvent power of Chloroform.*—The powerful solvent capabilities of chloroform are now, by experiment, fully established. Caoutchouc, resin, copal and gum-lac, bromine, iodine, the essential oils, &c., yield to its solvent power. This property may, it is believed, prove extensively of advantage in many of the fine and useful arts.

## LOCOMOTIVE CARRIAGE WHEELS.

Edward Evans, of the Haigh Foundry Company, has obtained a patent for "*certain Improvements in the mode of constructing iron wheels.*"—Granted October 28, 1847; Enrolled April 28, 1848.

This invention consists in a mode of securing the tyre or hoop of th ewheel to the spokes or inner rim, without the use of bolts or rivets. The patentee effects this object by using a dovetail groove in the tyre, and a dovetail projection on the rim, which is a method that has been previously adopted, therefore he makes no claim to that; but the peculiarity of his invention consists in making the groove larger than the projections, and filling the interstices with melted zinc. In the words of the specification, the patentee claims "the manufacture of wheels in which the dovetail groove in the tyre is wider at its narrowest part than the dovetail projection on the spokes or the inner rim of the wheel is at its widest part, and the filling the spaces left when the tyre is shrunk on with melted metal or other hard substance. The accompanying section



of the tyre and its junction with the wheel, will sufficiently show the form of the grooves and projections. The dark portions represent the zinc or other easily-fusible metal with which the spaces are filled.

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Locomotive Engines.—George Heaton, Birmingham, engineer, has obtained a patent for "*Improvements in locomotive engines.*" Granted November 9, 1847; Enrolled May 9, 1848.—The object of this invention is to prevent the oscillation of locomotive engines on railways; and the patentee endeavours to effect this by the application of counter-balance weights, moving in an opposite direction to the pistons of the cylinders. The mode of applying these counter-balance weights is as follows:—On each end of the axle of the driving-wheels is placed a crank, to which is united a connecting-rod attached at the other end to the counter-balance weight, which is suspended between two rods, so as to swing readily to and fro, or it is held between fixed guide-rods, to admit of its sliding easily. The counter-balance weights should always move in the direction opposed to that of the pistons, and should be as heavy as the combined weight of the pistons and the working-gear.

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Compound Beams or Girders.—Henry Fielder, Maida-vale, has obtained a patent for "*Improvements in iron beams or girders.*" Granted November 9, 1847; Enrolled May 9, 1848.—The patentee constructs his beams partly of malleable, and partly of cast-iron. The lower or tension flanges are made wholly or partly of malleable iron, while the centre ribs and upper or crushing flanges are wholly or partly of cast-iron, according to the duties they have to perform. The lower flange may be made of, or strengthened by the addition of malleable iron, and the centre rib and upper flange remain of cast-iron; or, the upper and lower flanges may be of malleable iron, united to the centre cast-iron rib, and further strengthened, when exposed to vibration, by angle-iron; or, the perpendicular ribs may also be composed of malleable iron, when exposed to violent concussions. The malleable iron is united to the cast-iron by hot rivetting, and, in all cases, in such proportion that it shall be able to support, alone, the estimated weight to which the whole girder may be subjected. The invention consists secondly, in the application of the preceding principle of construction to the strengthen-long or repairing of existing beams or girders, with such variation of detail as the particular case may suggest; and thirdly, to the construction of beams or girders composed entirely of malleable iron, in which case the flanges are united to the centre rib by angle-iron, the coupling-joints headed, and the whole are fastened together by hot rivetting.

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## ELECTRICITY OF MINERAL VEINS.

Mr. Robert Hunt (keeper of mining records at the Museum of Economic Geology) lately delivered a lecture on the "*Electricity of Mineral Veins,*" at the Royal Institution, Albemarle-street.

The lecturer commenced by remarking, that the class of phenomena which would form the subject of consideration that evening, although of the highest interest, had not yet received so great an amount of experimental examination as their importance required; and, as their curious nature was, consequently, not generally known, he trusted that, having spent many days and nights in the mines of Cornwall, in this investigation, he should be able to interest his audience by a narrative of the facts now known, as well as some of a novel character.

As a preliminary of absolute necessity, Mr. Hunt explained the nature of a mineral lode by the aid of a beautiful isometrical drawing of the lead district of Nentsford. A lode was, in fact, a fissure, formed by some disturbance of the earth, and filled with mineral deposits. Three theories prevailed as to the origin of mineral lodes; in the first place, they were supposed to be contemporaneous with the rocks themselves; secondly, it was conceived, that fissures were filled by the sublimation of matter from great depths in the earth; and, lastly, that substances were precipitated from solution in water, which flowed through those great rents in the earth. A mineral lode was not to be regarded as being entirely composed of metallic substances; on the contrary, they were most frequently found containing a large portion of earthy matter, amongst which the metallic ore was disseminated. Among the indications which appeared to support the theory of electrical action in these formations, was to be regarded the regular disposition of these substances on either side of the lode. The electrical theory might be explained in a few words. Ampere supposed that currents of electricity traversed the earth from east to west, and these currents were thought to influence the chemical changes which had gone on within the fissure during the formation of the lode, and determine the order of arrangement. The most striking conditions which appeared favourable to such a view were, that metals of various kinds were associated with peculiar classes of rocks—tin and copper being associated, in a remarkable manner, with the primary rocks; whilst lead was found more abundantly in the limestone formations. These rules, although general, were not constant—many striking exceptions might be named. In the remarkable mining county of Cornwall the rocks were granite, killas or clay-slate, greenstone, and elvan. The mineral lodes were always most abundant near the junction of the slate and granite rocks; they were generally found in a direction nearly from north-east to south-west; and where they were contrary to this, or nearly in the line of the magnetic meridian, there was almost invariably a great difference in the character of mineral substances contained in the lode. This was shown by reference to a very large map of Cornwall, upon which the lodes of lead and copper were accurately marked. Again, a very remarkable parallelism was observed in most districts between the directions of the lodes, and the veins of granite prophyry (elvan) which occurred in their vicinity; and this fact had been brought in support of the theory, which refers mineral formations to the action of subterranean heat.

The various questions which arose out of the phenomena of mineral veins, and their including rocks, had been most ably treated of by Sir Henry De la Beche, Mr. Joseph Carne, Mr. R. W. Fox, Mr. John Taylor, Mr. Hopkins, and others; he would not, therefore, dwell on that part of the subject.

Mr. Hunt next considered, whether any of the conditions known to belong to the rock formations of a mining district were sufficient to produce electrical phenomena. It had been ascertained that granite was always colder than slate—a difference of 20° or 30° was always detected at all depths. This difference might possibly give rise to weak thermo-electric currents; but, in the experiments he had made to ascertain this point, no such currents had been detected. It was also well known that a constantly increasing temperature was discovered as we descended into the earth. By this means, it was evident that any given portion would represent a bar unequally heated. The following table of temperatures, obtained in the rock and lode, exhibited the variations of temperature in the deep mine of Tresavean:—

| | | |
|---|---|---|
| At sea level.. | In granite.. .. | 57° F. |
| At 170 fms.. .. | Lode in slate .. | 77° F. |
| At 196 fms.. .. | Do in granite .. | 83° F. |
| At 208 fms.. .. | Do in granite .. | 85° F. |
| At 310 fms.. .. | In granite .. | 94° F. |

According to the generally received views of thermo-electric

action, such differences would be sufficient to produce currents. That was undoubtedly the case in metallic and good conducting bodies, but no such result had been obtained from experiments on granite, slate, or greenstone.

[A series of experiments was here introduced—and, notwithstanding the use of an active galvanic series, it was shown that the voltaic current would not transverse either granite, slate, elvan, or greenstone—connection being made with them and a very delicate galvanometer, upon which not the slightest indication of any action on the needles could be observed.]

When moist, these rocks became over their surfaces conductors; and, by this means, the action on a single pair of zinc and copper plates, not more than an inch square, was detected through a considerable extent of country. Mr. W. J. Henwood had supposed that he had detected currents of voltaic electricity through the granite and slate rocks of Cornwall; but the lecturer, who had repeated those experiments with great care, was led to believe that the slight deflection of the needle obtained was due entirely to some chemical action in the wires employed at the point of contact with the rock, or within its length—such slight disturbances being of constant occurrence in all experiments of this class. Although there was not, therefore, any experimental evidence in proof of the voltaic condition of the rocks, yet the regularity of arrangement observed in the lodes themselves—in which zinc, copper and quartz, lime, pyrites, barytes, fluor-spar, argentiferous lead, and quartz, alternated in the most regular order, as was shown by specimens from the mines of Cornwall, Derbyshire, Saxony, and Mexico—present features so analogous to those which often appear in galvanic experiments, that we are compelled certainly to infer that some modification of the electric force was concerned in the phenomena. Specimens of pseudo-morphous bodies from the Cornish mines, and arrangements of brown spar upon quartz, from Schemnitz, quartz upon fluor-spar, and iron pyrites, and the double sulphuret of copper upon large quartz crystals, in all of which a uniform system of arrangement, perfectly independent of each other, was shown—and these were to be referred, in all probability, to the disposing power of electrical currents.

Such were the principal evidences to be adduced in support of the electrical theory. Mr. R. W. Fox was the first to discover any indications of electricity in mineral lodes. By placing copper wires against two portions of a lode, or of two lodes divided by a cross-course, and connecting those wires with a galvanometer, a considerable deflection of the needle was obtained—often to such an extent, that from the violence of the action, it was impossible to note the deflection. In nearly all the mineral lodes of Cornwall, upon which experiments were made, these currents had been detected. Experiments made by Mr. Fox, in Coldberry and Skeers, in Teesdale, gave, however, negative results; and the results on the lead lodes at the Mold mines were not very decided. Prof. Reich, of Freyburg, obtained very decided results upon the lead and silver lodes of that district; and, in one case, succeeded in detecting a mass of silver ore at some distance behind the rock. Von Strombeck, on the contrary, could obtain no results from the lead and copper lodes on the right bank of the Rhine. In addition to these results, others of a most satisfactory kind had been obtained by Mr. Henwood and Mr. John Arthur Phillips. The lecturer had himself almost invariably obtained very decided galvanometric indications from the copper lodes of Dolcoath, East Wheal Crofty, East Pool, and other Cornish mines—in one instance so powerfully, that the electro-chemical decomposition was produced. Mr. Fox has been successful in procuring an electrotype copy of an engraved plate by the current collected from two lodes of iron and of copper pyrites, and also in inducing magnetism in a bar of soft iron. Mr. Pattinson, at the wish of the British Association, made a series of experiments on the rocks of the limestone formation in the lead districts of the north; but he could not detect any evidence of electrical currents.

It now became a question, to ascertain if these currents of electricity, detected in mineral lodes, were in any way connected with the general currents traversing the earth, according to the theory of Ampere; or, were they of a more local character? The lecturer was induced to conclude, from all his experiments and observations, that these currents were entirely local, and due to the chemical action going on within the lode itself. In all cases where chemical action could be detected, it was certain the current acting on the galvanometer was more energetic than where no chemical change was apparent. In this way might be accounted for the failure of Von Strombeck on the lead and copper lodes of the Rhine, and of Mr. R. W. Fox himself on the lodes of Teesdale—in all probability, those lodes being in a very permanent condition. It was thought by the lecturer that the fact, that these currents often being found to traverse the lodes in a direction contrary to the currents of Ampere, and frequently at right angles to them, militated against that view which referred the one to the influence of the other. The lecturer had also detected currents from piles of ore on the surface, which had been exposed to the influences of the atmosphere; and these currents were certainly only measurers of the amount of chemical action going on in the pile.

That these local lode currents might have a powerful effect upon masses of matter exposed to their influences, was highly probable; and he was disposed to refer the conditions in which cobalt and nickel were often found in the cross-courses, between the ends of dislocated lodes, as due to this local chemical electricity. The character of many of the decomposing lodes was next described; and it was shown that, under the influence of the percolation of rain-water from the surface, charged with oxygen, and the action of the saline water rising from below, few lodes admitting water to flow through them could be free from chemical action. He had analysed the waters of many of the deep mines, and the following were the results of a few of these analyses:—

The water from Great St. George contained, in a cubic foot, 590 grains of common salt; that of the United Mines, rising hot, 481 grains; of Dolcoath, 218 grains; of Great Wheal Charles, 612 grains; Consolidated Mines, at 80 fathoms, 656 grains; and at the 250 fathom level, 918 grains. This muriate of soda was estimated quite independently of the earthy and mineral salts. It was, doubtless, derived by infiltration from the ocean; and, from its quantity, acted, no doubt, powerfully upon the lodes it traversed.

Although these currents, detected by the galvanometer, were not regarded by the lecturer as in any way proving electrical agency in the formation of mineral veins, yet the evidence obtained by Mr. Fox, by Mr. Jordan, and more recently by himself, that electricity would give to clay a schistose structure and form along a curved line, no doubt related to some line of electrical action, a miniature lode of copper (of which illustrations were exhibited), supported the general view of electrical action. Incidentally, the conducting powers of iron and copper pyrites, galena, and some other minerals, were experimentally shown; and also the decomposition of yellow ore by electrical action.

In conclusion, the lecturer carefully recapitulated all the main points of evidence, for and against the electrical views, and pointed out many very curious circumstances, evidently dependent upon some peculiar conditions of the adjacent rocks, but which could not be referred, with any certainty, to electrical action. Probably, those currents now nearly determined as in constant flow around the earth, might produce the curious results observed; but a far larger amount of experimental evidence than that yet obtained was required, before this view could be admitted as one of the received facts of inductive science.

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## NOTES OF THE MONTH.

*Baron de Goldsmid's House.*—The grand ball-room at St. John's Lodge in the Regent's Park, of which so much has been spoken and written, was lighted last week, for a party given by the Baron de Goldsmid. The effect is reported to have been most admirable. Although Mr. Barry and Mr. Poynter had exerted every care, the effect of light upon the decorations must have caused them some anxiety, and it must be most gratifying to them to have succeeded so completely. The richness of the gilding contributes to the grandeur of the room, without destroying its air of chasteness; and if Mr. Barry be reproached that there is a want of repose in the House of Lords, and too great profusion of ornamentation, the same objection cannot be made against a ball-room. This saloon is the great work of the present season, and it is pleasing to learn that the munificent patronage of the Baron de Goldsmid has been, as usual with him, displayed in the encouragement of English artists, instead of being lavished upon foreigners, as is too common with our nobility.

*Mineral Produce of Austria.*—The latest published government accounts give the following as the mineral produce of Austria:—Gold, 35 cwt.; silver, 547 cwt.; mercury, 166½ tons; iron, 148,379 tons; copper, 2,753 tons; lead, 6,666 tons; litharge, 1,299 tons; zinc, 227 tons; calamine, 908 tons; tin, 49 tons; antimony, 231 tons; cobalt, 132 tons; manganese, 6¾ tons; arsenic, 50 tons; plumbago, 1,327 tons; alum, 1,494 tons; sulphate of iron, 5,354 tons; sulphate of copper, 288 tons; sulphur, 1,259 tons; coal, 524 tons.

*The Holyhead Steam-Packets.*—The principal trial of the new Holyhead steam-packet *Llewellyn*, master, Commander Grey—vessel and engines designed and manufactured by Miller, Ravenhill, and Co., of Blackwall—took place on Monday, the 15th ult. It is stated that, under adverse circumstances, she made four uns at the measured mile, at Long Reach, which

gave her an average rate of speed of 15·415 nautical miles, or nearly 17¾ statute miles per hour, never making less than 27 revolutions per minute. She then run to the Nore light, passing the distance from the town pier at Gravesend, in *one hour and fifteen seconds;* and then ran from the Nore light to the Mouse light and back twice, during which time her greatest speed was 20½ statute miles per hour, and her lowest rate at 15·845. The latter, however, in consequence of the throttle-valve being open, was held to be a bad trial, and she was accordingly tried up and down again the 7·65 knots' distance. When working at 28 and 29 revolutions per minute, she made the same run down in 27 minutes 22 seconds, or at the rate of 16·798 knots; and the return trip in 30½ minutes, or at the rate of 15·049 knots. Taking the average of the two last runs, the speed of the *Llewellyn* was nearly 16 nautical miles an hour, or 18½ statute miles per hour.

*The New Steam-Ship Basin at Portsmouth.*—This national work, which has been constructed with the view of affording to steam-ships a fitting and convenient place of reception, was opened on Thursday, the 25th of May. The first stone was laid January 13th, 1845. Its original design was far of far less magnitude, but as the work progressed, enlargements and improvements were suggested, until the plans were finally extended to their present spacious dimensions. Its mean average length is 774 feet, 400 feet wide, and 31 feet deep from the coping, covering an area of more than seven acres. The entrance is 80 feet wide, and the depth of water at the lowest tides 21 feet. There is also a fine wharfage outside the basin, in the harbour, where there is water to the depth of 13 feet, which is sufficient to accommodate second-class steamers. There are two inlets on the east side of the basin, each 300 feet long by 70 wide, and 30 feet deep from the coping; these are to enable vessels, whole refitments must be completed in a hurry, to be worked upon by the artisans on both sides at once. On the west brink of the basin is a great factory, of handsome architecture, 687 feet long, 48 feet wide, and 51 high, and is partially roofed in. On the south wall is a new brass foundry, 90 feet by 110, which has been for some time in partial working. The basin is considered capable of accommodating around its sides nine steam frigates of the first class, and has employed, on the average, 1,500 men since the commencement, besides an immense body to whom it has given work off the premises—in the quarries, forests, iron works, &c. Besides the above materials, there have been used in various parts of the whole about 2,500 tons of cast iron from Staffordshire. The rough cost of the labour already turned out of hand is £400,000.

*Sudden Draining of the Niagara River.*—The following extract of a letter we have received from the United States, describes a very curious phenomenon, which recently alarmed the residents near the Falls of Niagara:—"The good people at the falls were greatly alarmed a few weeks ago, fearing that the bottom of the river had fallen out; for all at once the mills ceased to work, and great part of the falls on Table-Rock were bare. The river, a little above Goat Island, was bare for half the distance across. A gentleman drove his wagon on the bare rock to the middle of the bed of the river, where to have ventured the day previous would have been certain death. The worst fears were entertained; some believed the world was coming to an end—indeed, fear was stamped on every countenance till the cause was explained. The fact was, that a quantity of ice on Lake Erie had drifted to the mouth of the river, and impeded its flow."

*Suspension Bridge near the Falls of Niagara.*—The first car, suspended by a wire cable, crossed from cliff to cliff below the falls of Niagara on the 13th of March. Mr. Ellett, the engineer who has undertaken the construction of the suspension-bridge at that place, was the first person who crossed over, amidst the cheers of a large concourse of people. The *Toronto Colonist* observes: "Mr. Ellett must feel gratification and commendable pride that he is the first man who ever crossed in a carriage through the air, on wire, from one empire to another; thereby, it is to be hoped, leading to a happy, prosperous, generous, and reciprocal union—a firm chain of friendship between mother and daughter." We may suppose that among those who experienced alarm at the sudden draining of the Niagara river, noticed above, the shareholders in the suspension-bridge undertaking, were not less frightened than the others.

*Communications in Railway Trains.*—Another of the many plans proposed for establishing a communication between the passengers and the guard, and through him with the engineer, on railway trains, has been recently patented. The inventor of this plan is Mr. Edward Tattersall, of Newmarket, land surveyor; and it consists in having a cord run along the tops of all the carriages, communicating with the handle of the steam-whistle, or with a bell. The patentee claims as new an apparatus for lengthening or shortening the cord, without requiring it to be drawn out longitudinally. To enable the passengers to communicate with the guard, a lamp by night, and a signal board by day, is to be fixed to the top of each carriage, and the passenger, by pulling a string may raise a flap that ordinarily secures the lamp or signal-board, and when the guard sees this notice, he is to pull the cord to order the engine-driver to stop.

*Iron Ore in Algiers.*—A report presented to the Paris Academy of Sciences, on a communication made by M. Fournel, respecting the mineral wealth of Algiers, represents the iron ore to be extremely abundant and rich. In the mountains of Bou Hamra, throughout a distance of four leagues, the croppings-out of a considerable number of beds of ore may be observed, attaining sometimes a considerable size, and never less than from four to five yards in depth. At the north of Fizara there is an entire mountain (the Mohta El Hadad, or iron quarry), which rises out of the gneiss, and literally presents from its base to its summit, that is to say, a height of about 108 yards, one mass of pure oxide of iron, without the admixture of any other substance. To the east of this mountain, M. Fournel traced upwards of 16 points where the ore was cropped-out. M. Fournel has also found large quantities of ancient scoriæ, proving that these sources of mineral wealth had been worked by the Romans, or perhaps by the Vandals; there are also scattered amongst these scoriæ, specimens of the metal produced, so that by analysis it can be ascertained from which bed of ore the metal produced at such and such a point, was obtained.

*Copying Electric Telegraph.*—An electric telegraph which will produce at a distant town *facsimile* copies of writing applied to the instrument in London, has just been invented by Mr. F. C. Bakewell. We have seen a specimen of the telegraphic writing copied from the original by a separate instrument, only connected with the other by wires in the ordinary manner. We understand that arrangements are being made to give the invention a trial at a long distance, for the purpose of adopting this mode of telegraphic communication generally, if it be found equally applicable between distant towns as it is at short intervals. The rapidity with which copies may be made with this instrument, will far exceed the manual dexterity of the quickest writer; for the inventor expects to be able to transmit 500 alphabetical letters per minute. Where short-hand is employed, of course the rapidity of transmission would be much greater; and we understand that even plans and drawings may be copied by the same instrument.

*Phosphates in the Green Sand.*—The green sand formation, situated under the chalk, contains fossil substances in such abundance as to render them valuable as manures, in consequence of the phosphate of lime which is thus obtained. Attention has been recently directed to this subject, and if the fertilizing properties of green sand be as great as is represented, there exists in the south of England vast stores of manure, corresponding in chemical properties with the guano that has been scraped from distant islands, and sold at a high cost in this country. The presence of coprolite (dungstone) nodules in the upper green sand and gault, was pointed out by Dr. Fitton several years ago, in his account of the "beds below the chalk," published in the "Transactions of the Geological Society," vol. iv. second series; and Dr. F. also ascertained the large proportion of phosphate of lime contained in these bodies. Dr. Fitton's observations were chiefly made from the gault at Folkestone. But he has also noticed the existence of these nodules in various parts of the upper and lower green sand. There are cliffs of the upper green sand at Eastbourne, in Sussex, where the fossil and coprolitic nodules may be found. If we pass from the out-crop of the green sand in Sussex and Surrey, we find it again in still greater force westward, in the fertile vale of Pewsy, one of the finest pieces of wheat land in the kingdom. The whole valley from Bedwin to Devizes is coveredwith this soil, the stratum dipping under the chalk of the Marlborough downs on the north and Salisbury plain on the south.

*Improved Machine for Rolling Iron.*—Mr. Benjamin Norton, of Boonton, New Jersey, U.S., has recently obtained a patent in America, for an improvement in the machine for rolling iron. In describing his invention, the patentee says—"In rolling the billets of iron that are to be converted into hoop-iron, or into scroll, band, or other iron of a like character, the apparatus used, as ordinarily constructed, consists of three rollers, the axes of which are in the same vertical plane. The billet is passed through a groove in the lowermost pair, and is returned through a groove in the uppermost pair, by which it is prepared to be passed through the smooth or finishing rollers. In my improved apparatus I use but two rollers, in which the billet is first passed in the usual way; as it passes from between these rollers on the rear side, it enters a curved trough, which I call a receiver, and this trough conducts it round the rear side of the upper roller towards the workman in front, who passes it into the groove in the first instance, and who then passes it into a second groove, formed in the same rollers; by which arrangement much time and friction are saved, and other obvious advantages obtained. The patentee claims the combination of the covered trough, or receiver, with a pair of rollers, for the purpose of conveying the strand to the front of the rollers, in combination with the employment of the second groove, or grooves, in the lower roller, and thereby admitting of the widening out of the collars.

*Ether a substitute for Steam.*—M. Zede, Director of the Ports of France, at the request of M. Lafond, a lieutenant in the Marine Navy, has made several experiments on the employment of the vapour of ether in one of the cylinders of a steam-engine. The results were very satisfactory as far as regards the employment of the mechanical force contained in this vapour; but as regards safety, M. Zede stated that it is impossible to conceive the danger arising from the use of so inflammable a liquid as sulphuric ether. In order to remove this objection, M. Lafond has proposed to him the employment of chloroform in place of ether.

*Cause of Rain.*—At a recent meeting of the Paris Academy of Sciences, M. Babinet explained his theory of the cause of rain, founded on numerous observations. He supposes that a volume of humid and heated air having risen into the upper regions of the atmosphere, expands in the rarer air; consequently, the temperature becomes lowered, and the vapour condenses and is precipitated in rain. There seems to be nothing new in this theory, and it fails to assign an intelligible cause for the observed phenomena of rain. It is founded also on the questionable assumption, that the portions of the atmosphere near the earth rise when heated into the strata of air above; because, in most circumstances, the difference in the pressure of the atmosphere at higher elevations, causes a greater difference

in the relative weights of equal volumes than the different degrees of heat above and below. M. Babinet, indeed, seems to admit this, as the expansion of the humid air he supposes to be caused by the rarer state of the upper atmosphere, and yet he seems to have forgotten to take into consi- that the denser and heavier air would not rise into the lighter.

*Analysis of Phosphates.*—Messrs. Dumas and Pelouze have reported very favourably of the process adopted by M. Raewsky, to ascertain the proportions of phosphoric acid contained in phosphates. The process consists in bringing the phosphoric acid to the state of phosphate of the peroxide of iron, and then to ascertain the quantity of iron which it contains. As the phosphate of the peroxide of iron is insoluble in acetic acid, in precipitating the phosphoric acid from an acid liquor by means of the acetate of the peroxide of iron, the salt will be precipitated pure, and can consequently be collected in a filter. After a careful washing, if it be dissolved in nitric acid, and reduced to the minimum state of oxidation by the acid of a suitable addition of sulphate of soda, there will remain only to saturate the iron restored to this state by means of the proportionate quantity of permanganic acid necessary to convert it again into peroxide.

*Rotary Heels.*—A patent has been taken out for rotary heels to boots and shoes, so that, however unevenly a person may tread, the heel may be regularly worn by giving it a turn daily, to expose a fresh surface at the part most trodden on.

*Invisible Musicians.*—Mr. A. Bain, the ingenious inventor of electric telegraphs and clocks, has obtained a patent for an invention, part of which consists in causing musical instruments to be played by electro-magnetism, without the apparent agency of any musician. He effects this by placing electro-magnets under the keys of the instrument, and these magnets are connected by wires with some other similar instrument in another room, or it may be in some other part of the same town. Whenever one of the keys of the original instrument is pressed down by the performer, it completes the electric circuit, and induces magnetism in the temporary magnet under the corresponding key of the distant instrument, and that is instantly drawn down and sounds the note. This arrangement might be continued through several instruments, every one of which would be played at the same time by one performer, who would be touching the keys of only one instrument, and that, perhaps, a mile apart from the others. In another part of Mr. Bain's invention, he proposes to dispense with performers altogether, and to make the printed music play itself. This is done by perforating holes in a sheet of paper, which is to be drawn over the openings of wind instruments. Whenever the perforated holes coincide with the orifices in the instrument, the notes are sounded; and by arranging the perforations at their proper distances, the tune is played!

*Manufacture of White Lead.*—Some improvements in the manufacture of carbonate of lead have recently been patented by M. Jean Marie Fourmentin, of New Bridge-street, Blackfriars. In this process, the carbonate of lead is produced by the decomposition of oxichloride of lead (obtained by the action of sea salt upon protoxide of lead), by means of carbonic acid, which decomposes the oxichloride; an insoluble carbonate of lead being produced, and a solution of chloride of sodium remaining.

*Triple Railway Break.*—A model of a triple railway break, invented by M. Laignet, has been submitted to the Paris Academy of Sciences. Each part of the break must be successively destroyed before any material damage can be done, and the resistance offered is calculated to be sufficient completely to overcome the momentum of the train. The action of the break is independent of the engine-driver, and it is constantly ready to act when occasion requires. The name given to this break is *Parachoc*.

*New Rifle-Barrel.*—A new mode of forming the spiral-inside rifle-barrels has been registered by Mr. Lancaster. Instead of making the spiral of a regular helical form throughout, that form is adopted only in the first half of the barrel, commencing at the breech; the other portion being on an uniformly accelerating geometric curve. The advantages said to be gained by this method are—diminution of the recoil, a sustained spiral motion without the present liability in rifles of stripping the ball, and a larger range with the same charge of powder.

*The College at Putney.*—The Admiralty experiments on coals for the steam navy, are continued at Putney College, in the buildings erected there by government for the purpose. Dr. Lyon Playfair has recently constructed for this College, the largest magnet that has hitherto been made.

*Mammoth Machine.*—The *Renfrewshire Reformer* notices the manufacture by Messrs. T. Shanks, of Johnstone, an immense sloting machine for cutting and dressing up, by self-action, the cranks and cross-heads of the largest marine steam-engines, finishing them throughout, from the rough block as they come from the forge. The machine is erecting for Messsrs. Fulton and Neilson, of Lancefield Forge, and the weight of the single casting which forms its base is 28 tons. This cast was executed by Messrs. John Goldie and Co., of the Hayfield Foundry, and took four months in the moulding.

*Manual Power Locomotive.*—A Manchester paper states, that Mr. Archibald Farrie, an ingenious mechanic of that town, has invented a locomotive to be propelled by manual labour, which was successfully tried along several of the streets of Manchester. The carriage was stopped every now and then, to allow parties to inspect the movement of the machine—the working of which appeared to cause the driver only a slight muscular effort, aided by manual dexterity. The machine weighs 8 cwt., has no cranks, and has been worked by one man up an incline of 3 feet in the yard, while twelve persons were in it.

## LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM APRIL 27, TO MAY 26, 1848.

*Six Months allowed for Enrolment, unless otherwise expressed.*

William Newton, of Chancery-lane, Middlesex, civil engineer, for "Improvements in machinery for burring, ginning, and carding wool and cotton or similar fibrous materials requiring those processes." (A communication.)—Sealed April 27.

Edward Walmsley, of Heaton Norris, Lancashire, cotton spinner, for "certain Improved apparatus for preventing the explosion of steam boilers."—Apri 217.

William Henry Barlow, of Derby, civil engineer, and Thomas Forster, of Streatham Common, Surrey, gentleman, for "Improvements in electric telegraphs and in apparatus connected therewith."—April 27.

Thomas Edmondson, of Manchester, machinist, for "Improvements in marking and numbering railway and other tickets or surfaces, and in arranging and distributing tickets."—April 27.

Daniel Rice Pratt, of Worcester, in the State of Massachusetts, America, for "machinery for connecting railway carriages."—April 27.

James K. Howe, of the city of New York, in the United States of America, for "Improvements in building ships and other vessels."—April 27.

Roger George Salter, of Birkenhead, in the county of Chester, surveyor, for "certain Improvements in carts for the distribution of liquid substances, and in the construction of drains, sewers, and cesspools, and in the cleansing of the same."—April 27.

Charles Fielding Palmer, of Birmingham, for "a new or improved chalybeate water."—April 27.

Alexander Parkes, of Birmingham, experimental chemist, for "Improvements in the manufacture of metals and in coating metals."—April 27.

William John Normanville, of Park Village, Middlesex, gentleman, for "certain Improvements in railway or other carriages, partly consisting of new modes of constructing the axle-boxes and journals of wheels; also an improved method of lubricating the said journals or other portions of machinery, by the introduction of aqueous, alkaline, oleaginous, or saponaceous solutions."—May 2.

Isaac Harles, of Rosedale Abbey, Yorkshire, farmer, for "certain Improvements in machines or machinery foharrowing, sowing, and manuring land."—May 2.

Isaiah Davies, of Birmingham, engineer, for "Improvements in steam-engines and locomotive carriages, parts of which are also applicable to other motive machinery."—May 2.

Alexander Southwood Stocker, of York-place, City-road, Middlesex, gentleman, for "certain Improvements in time teachers and boxes, show cards, or holders for matches, pens, pins, needles, and other articles, and in the mode or modes of manufacturing the same."—May 2.

Felicité Raison Selligue, of 6, Boulevart Beaumarchais, Paris, for "certain Improvements in propelling, and the machinery employed therein." (A communication from her late husband.)—May 2.

Henry William Schwartz, of Great Saint Helen's, London, merchant, for "Improvements in steam engines." (A communication.)—May 2.

Lewis Dunbar Brodie Gordon, of Abingdon-street, City, for "an Improvement or improvements in railways."—May 9.

William McLardy, of Salford, Lancashire, manager, and Joseph Lewis, of the same place, machine-maker, for "certain Improvements in machinery or apparatus applicable to the preparation and spinning of cotton, wool, silk, flax, and other fibrous substances."—May 9.

Richard Laming, of Clichy la Garonne, in the republic of France, for "an Improvement or improvements in the manufacture of oxalic acid."—May 9.

Edward Haigh, of Wakefield, plumber, for "an invention for measuring water or any other fluid."—May 9.

Vincent Price, of Wardour-street, Soho, Middlesex, machinist, for "certain new or improved mechanical arrangements for obtaining and applying motive power."—May 11.

Charles Hancock, of Brompton, Middlesex, gentleman, for "certain Improved preparations and compounds of gutta percha, and certain improvements in the manufacture of articles and fabrics composed of gutta percha alone, and in combination with other substances."—May 11.

Thomas Restell, of Tooting, Surrey, watch-maker; and Richard Clark, of the Strand, Westminster, lamp-manufacturer, for "Improvements in chronometers, clocks, watches, and other time-keepers."—May 11.

George Armstrong, of Newcastle-upon-Tyne, engineer, for "an Improved water-pressure engine."—May 11.

Mark Smith, of Heywood, Lancashire, power-loom maker, for "certain Improvements in looms for weaving."—May 11.

William Taylor, of Birmingham, mechanist, for "an Improved mode of turning up or bending flat plates of malleable metals, or mixture of metals, by aid of machinery, into tubes."—May 18.

George Henry Bursill, of Albany-place, Hornsey-road, James Paterson, of Baldwin street, City-road, and John Mathews, of Norman's-buildings, Old-street, engineers, Middlesex, for "a certain Improved method or methods of treating malt liquors and other liquids or fluids, and certain improvements in machinery or apparatus for effecting such improved method or methods of treatment."—May 22.

Abraham Solomons, of London, merchant, and Bondy Azulay, of Rotherhithe, Surrey, printer, for "Improvements in the manufacture of gas, tar, charcoal, and certain acids."—May 26.

Matthew Hague, of Waterhead Mills, Lancashire, machine maker, and Joseph Firth of Huddersfield, Yorkshire, cotton doubler, for "certain Improvements in machinery fo twisting and doubling cotton yarns and other fibrous materials."—May 26.

Moses Poole, of London, gentleman, for "Improvements in propelling vessels." (A communication.)—May 26.

James Parker Percy, of Clarendon-place, Notting-hill, gentleman, for "certain Improvements in obtaining copper from copper ores."—May 26.

James Remington, of Warkworth, Northumberland, civil engineer, for "Improvements in locomotive engines, and in marine and stationary engines."—May 26.

Thomas Richardson, of Newcastle upon-Tyne, chemist, for "Improvements in the manufacture of manure."—May 26.

Felix Hyacinthe Folliet Louis, of Southwark, Surrey, gentleman, for "an Improv d method or process of preserving certain animal products."—May 26.

## IMPERIAL INSURANCE OFFICE, OLD BROAD St., CITY.

John Gibson, Esq., Architect.

*(With an Engraving, Plate IX.)*

The progress of insurance companies, the great interest which is felt by all classes in making a provision for the future, the establishment of new offices, and the extension of business, have caused a demand for large public buildings, of architectural pretensions, and capable of giving the required accommodation. Thus, the City, in addition to the halls of its corporations, its banks, and its dock buildings, has now many ornaments to boast of in the noble offices erected for transacting the business of the assurance companies. It has been fortunate, too, that with the rise of these establishments, there has been a concurrent improvement in public taste, which has been productive of emulation among the architects, and has given us each year a better class of works.

What the club is to the street architecture of the west-end, the assurance office is to the city; and the edifices devoted to the more useful purposes of life, it is pleasing to see, are not inferior to those which are only the appendages of luxury. Indeed, the range of assurance offices in London, constitutes in its architectural, as well as in its moral aspect, a characteristic of which England may be proud. The foreigner has hitherto envied us our charities, our parks, and our clubs; he will now have another feature in the physiognomy of London, which suggests honourable associations in connection with the private and domestic habits of the professional and middle classes, and testifies to their earnest and provident care for those to whose comfort their lives have been devoted.

The Sun, the Alliance, the Amicable, the Globe, and the Atlas, are but a few among the buildings which will readily suggest themselves as coming within the class we have mentioned, each the centre of operations of some great institution, in which property to a large amount is insured, or on which thousands of wives and of children depend for provision when widowhood or orphanage may be their lot. Of the architectural merits of most of the buildings named, we have had the opportunity of speaking on other occasions; we have now to add to our list the office of the Imperial Insurance Company.

The Imperial Fire Insurance Company was formed in 1803, under a deed of settlement by which the capital was declared to consist of 2,400 shares, of £500 each, but on which, only ten per cent. has ever been called. The invested capital now exceeds half a million, to secure a permanent dividend of twelve per cent., payable half-yearly, independently of bonuses which have hitherto been equal to as much more, and accounts for the shares being of greater value than those of any other existing similar establishment. The Life Office (which, although bearing the same name and carrying on its business under the same roof, is a totally distinct concern) was formed under a similar deed of settlement, in 1820. Its capital consists of 7,500 shares, of £100 each, on which only ten per cent. has ever been paid up; to secure a dividend on which, payable annually, an ample capital is invested in the public funds, independently of an accumulated premium fund now exceeding £700,000, and bonuses which are declared quinquennially.

The directors of these two companies, finding the accomodation afforded by the premises they have hitherto occupied in Sun-court, Cornhill, inadequate to the wants of the respective offices, determined, in September 1846, to erect others on the site they had purchased at the corner of Old Broad-street and Threadneedle-street; for which purpose, several architects were invited to furnish designs, and having done so, Mr. Shaw, one of the official referees was called in to assist the directors in their selection: that resolved on the adoption of Mr. Gibson's design, now nearly completed by the Messrs. Piper, who took the contract for the erection.

Mr. Gibson is the architect of the Baptist Chapel in Bloomsbury-street, of which we lately gave the elevation, and who may consider himself pre-eminently fortunate in being able to make his professional *debût* in two public structures, produced simultaneously. The one which forms the subject of our engraving this month, is the Imperial Insurance Office, which stands at the corner of Old Broad-street and Threadneedle-street. It is an astylar composition, of the Italian Palazzo style, executed in Portland stone, and has unquestionably made a very great improvement in that part of the city, if only by removing what used to be a very ugly and inconvenient sharp corner; in lieu of which, that angle is now cut off, and is made to form a distinct and distinguished compartment of the general design, and is so placed as to present itself to the eye in a very striking manner; and, with its two neighbouring buildings—the Hall of Commerce on one side, and the Mentor Assurance Office on the other—forms a rather important architectural group, in which there is certainly no lack of variety,—the Imperial Office being as studiedly ornate as the other two are studiedly simple, not to say severe and cold in style. Or perhaps we should qualify our opinion by saying, that the façade of the Hall of Commerce would look somewhat cold and bare as an architectural composition, were it not for the panel frieze, which is in a double sense a *relief*, and which, while it sets off the façade, is in turn set off by its very subdued tone of decoration. A similar universal degree and mode of embellishment in point of sculpture, is also a trait in the design of the Imperial Office, all the key-stones of its ground-floor windows being enriched with carved masks or heads upon them—not a mere repetition of each other, but varying in character,—while the large panel in the upper part of the south-west compartment, between the Threadneedle-street and the Broad-street fronts, will display a relievo, consisting of two sitting female figures, considerably above life-size, with three shields between them, bearing the arms of England, Scotland, and Ireland:—which piece of sculpture, and the key-stones just mentioned (amounting in all to fourteen in the two fronts), are by Mr. Thomas, an artist extensively employed at the new Palace of Westminster. Highly satisfactory is it to perceive such attention to artistic finish bestowed upon a building which, had it been erected some dozen or fifteen years ago, would have been turned out of hand very differently,—both with the minimum of detail and with the minimum of design bestowed upon *that*, as witness the Alliance Office, in Bartholomew-lane, and the "Atlas," in Cheapside,—or the City Club-house, in Broad-street; all of which may claim the merit of being exceedingly simple and unartificial—provided unartifical and *unartistic* be synonymous and convertible terms. The Imperial Office has been enriched with great propriety, the ornaments being in perfect keeping throughout, and at the same time they are profuse and well-executed.

We can now only allude to the interior, as it is not yet quite finished; but every attention appears to have been bestowed upon the official arrangements, and every precaution taken to render the Offices fire-proof. The "strong-room" has been fitted by Mr. Leadbeater with wrought-iron doors, filled with a chemical compound for making them perfectly fire-proof, and ventilating gates. This room appears to be a perfect pattern of safety.

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## CANDIDUS'S NOTE-BOOK, FASCICULUS LXXXIII.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. One of the essays in the piquant little volume, entitled "Friends in Council," is upon the subject of Public Improvements. As to the essay itself, it is disappointingly brief, and deals too much in, or rather is confined to, abstract generalities. There are, however, one or two remarks introduced in the subsequent conversation between the "Friends" themselves, that deserve to be pointed out. The first of them which I select would furnish matter for a discourse or paper of some length:—"*Milverton*: 'There is one thing I forgot to say,—that we want more individual will in building, I think. As it is at present, a great builder takes a plot of ground, and turns out innumerable houses, all alike—the same faults and merits running through each: thus adding to the general dulness of things.'"—Such system of house-manufacturing for the market operates, it must be confessed, very injuriously for architecture. A single design is made to serve for scores—perhaps hundreds, of houses; nor is much study bestowed upon that pattern or *matrix* design. So that it provides a sufficiently commodious dwelling, with all the useful routine accommodations looked for in a "respectable" house, and a sufficiently *tasty* appearance externally—for your builders deal largely in the "tasty," though not in the tasteful,—nothing more is thought of. London houses have no individuality: never do you find a single original or pet idea carefully worked out in any one of them. One advantage of this is, that you are as well acquainted with every nook and corner of your neighbour's house as you are with your own; another, that you are relieved from all responsibility on the score of taste, it being that of the confounded builders,—not your own.

II. To continue quoting:—in *Ellesmere's*—not the Earl's—reply, we meet with this somewhat perilous question:—"'By the way, Milverton, I want to ask you one thing. How is it that governments and committees, and the bodies that manage matters of taste, seem to be more tasteless than the average run of people? I will wager anything, that the cabmen round Trafalgar-square would have made a better thing of it than it is. If you had put before them several prints of Fountains, they would not have chosen those.'" To which Milverton responds: "'I think with you, but have no theory to account for it.'"—Partly, and even mainly, accounted for it might be, by saying: It is because in all such matters, committees hold themselves to be utterly irresponsible for their acts, and because no one cares to convince them of the contrary, by formally calling them to account. So long as Committees of Taste, or whatever else their actual designation may be, are suffered to carry on their councils and operations behind the curtain, what better can be expected than mere random experimentalizing and blundering, at John Bull's expense? He it is, the British Donkey, though flattered by being drawn as the British Lion, who pays for all.

III. "'Now, Milverton,'" says Ellesmere again, "'would you not forthwith pull down such things as Buckingham Palace, and the National Gallery?'" To which the reply is: "'I would pull them down to a certainty, or some parts of them at any rate; but whether "forthwith," is another question.'"—As Mr. Blore's *improvement* of the Palace had been commenced before the book here quoted from was published, we are at liberty to suppose that, in the writer's opinion, such improvement does not render pulling down at all the less desirable,—perhaps, even more so than ever. As affairs have since turned out, the times are not at all propitious for schemes of building either new Royal Palaces, or new National Galleries. With regard to the Gallery, notwithstanding its imperfections, it is susceptible of very decided improvement as it now stands,—capable of easily being made what it ought to have been at first. Even at present, it is not so much the "Gallery" itself, as the other buildings and accessories, that render Trafalgar-square a failure. Those on the east side are in the most pert and vulgar taste, and require to be pulled down quite as much, or even much more, than the "Gallery"—if anything is ever to be made of the Square as an architectural *ensemble*. As to the west side, the best that can be said of it is, that it serves as a foil to the "Gallery," and is more lucky than the latter; probably owing to its being sheltered from the shafts of criticism by the august name of Sir Robert Smirke. Indeed, it is somewhat unaccountable, that those who are so dissatisfied with both the Gallery and the Fountains, should be so complacently tolerant of all the rest, and even go into extasies of admiration of St. Martin's Church, which, the columns of the portico alone excepted, is a compound of tastelessness, uncouthness, and deformity. There is not a single feature in it that harmonizes with the order, or is at all in the spirit of the style so professed. In one respect, the Church and the Gallery are nearly on a par, it being difficult to decide which is the ugliest—the steeple of the one, or the dome of the other. Both the one and the other may be said to contrast with the respective porticoes; but there is a very wide difference between grating dissonance and that artistic contrast which, while it introduces variety and prevents too great sameness, contributes to general harmony. Of such contrast and harmony we have example in the human countenance, where the eyes and mouth are placed horizontally, and the nose forms a vertical line coming in between them. A *regular* and well-trained critic might object to this, and contend that nature is here at fault; and that there would be more pleasing regularity were either the nose placed in the same direction as the other features, or the latter in that of the nose. Still, there is very great comfort left for him, if not for us—namely, that there is *precedent*—aye, universal precedent—for noses being placed just as they are. But now I am getting too rigmarolish; therefore, break off.

IV. I find that I have omitted an observation in Milverton's reply to Ellesmere's sneer at the taste of governments and committees, that deserves to be attended to. "'I suppose,'" says the latter, "'that these committees are frequently hampered by other considerations than those which come before the public, when they are looking at the work done. And this may be some excuse. There was a custom which I have heard prevailed in former days in some of the Italian cities, of making large models of the works of art that were to adorn the city, and putting them up in the places intended for the works when finished, and then inviting criticism. It would really be a very good plan in some cases.'"—No doubt, but practicable only for small ornamental works, such as fountains, triumphal arches, public statues, monumental crosses, &c. A full-sized model of such an edifice as the "Houses of Parliament," or even of the new building at Buckingham Palace, would have been rather too cumbrous and costly an affair for an experiment of the kind. Had any other design been chosen for the purpose than the Corinthian column—a model of which would have been altogether superfluous—the Nelson Monument might properly enough have been tried beforehand, by means of a full-sized model of it put up on the spot. Yet, when we consider what a mere farce was played with the model, or what was meant for model, of the Wellington Statue on the Archway, which was allowed to remain up only two days, when it was snatched away, lest it should be pelted at with further volleys of censure and derision,—we must pronounce trial by model—at least, when so conducted—to be altogether nugatory. If the Statue-committee made a show of "inviting criticism," they showed also wonderful alacrity in running away from it, after its very first fire. Inviting criticism before-hand, forsooth! committees have no notion of doing that. Their policy invariably is to stave it off as long as they possibly can. The public, it will be recollected, were not permitted to see the model of the façade of the British Museum, notwithstanding that there was one in existence, and that in the building itself; and notwithstanding that some of the newspapers called out for its being liberated from durance under lock-and-key, and submitted to inspection and criticism. Well, we have now the façade itself, and see both positive faults and numerous short-comings, all which might have been foreseen in the model, and ought to have been corrected accordingly. It is true, the facade is not generally ill-spoken of,—simply because it is not spoken of at all. It obtains not so much as a syllable of praise in any quarter; and such silence is tolerably expressive of disapprobation and disappointment. The new building at Buckingham Palace, is in the same unenviable predicament. It has been abandoned to mockery and contempt, without a single favourable word for it having been uttered by any one; although there are some who would most readily have done so, had they not stood in awe of general discontent, and been apprehensive that they might injure their own credit with the public for judgment and taste, by attempting to persuade them that the design is at least not unsatisfactory.

V. So long as committees, and those who have the management of public competitions for buildings, shall continue to be left irresponsible for their doings, there will be no end to both blunders and dishonesty. Persons who intend to act honourably and fairly, do not need to screen themselves behind a curtain, thereby exciting a suspicion that what they do will not bear the gaze of broad daylight. On the other hand, those who care only for the opportunity of exerting their own private influence, without regard to aught besides—even honourable dealing being left out of the question—ought to be made aware that if they so act, it must be at their own peril. There is scarcely a public competition of any importance that does not occasion complaints of unfair intriguing, and of bad faith on the part of the committee,—complaints that can very well be endured; committees being sufficiently aware that with mere complaints, the matter complained of blows over, without proceeding to the extremity of exposure. All this is deplorable enough; but then, how is it to be remedied? I should say, that what would go very far towards remedying it, if not remedying it completely, would be the making it ILLEGAL for any committee, or other body, to invite architects to a competition by public advertisement, without having a public exhibition beforehand of the designs sent in in the first instance, and without entire publicity in all other respects, the names of the committee being published, and reporters for the press being admitted to their discussions on the relative merits of the designs. As matters are *cunningly* managed at present, we only know that Mr. A, or Mr. B's design has been selected for adoption; but how many votes, or who were the persons who voted for or against, it is impossible to learn, much less the arguments they made use of. The Army and Navy Club, who, it is to be presumed, call themselves gentlemen and men of honour, have laid themselves open to the imputation of the most bungling and bare-faced trickery, by calling an unlimited competition in the first instance, and afterwards setting that aside, and having a second one *limited to six*, of course of their own choosing, after the site (at first rather an inconvenient one, and therefore tasking all the ingenuity of the first competitors) had been considerably enlarged, by taking in another house in Pall-Mall. The Army and Navy Club ought to blush at being convicted of such downright knavery; yet, they will not do so, because they know that they are behind a curtain, and that the names of the committee *cannot* be shown up, as they deserve to be, as those of a pack of tricksy jugglers. One comfort, if a comfort it be, is, that they have tricked themselves; for from what has

been said of it, they seem to have got a most Pecksniffian plan for their building. Were I, as thank God I am not, a member of the Army and Navy Club, I should be tempted to hang myself out of pure vexation. After what they have done, Navy and Knavery are likely to become synonymous words.

VI. The idea of manufacturing the picturesque out of such things as labourers' cottages is not a little absurd; more especially, when two most embarrassing conditions are annexed to the task—first, that they shall be erected at a minimum of cost; secondly, that they shall be free from all those defects, discomforts, and inconveniences which accompany and contribute to picturesque quality in the works of village Vitruviuses, which marked in their *raw* state only by uncouthness and meanness, are touched, tinted, and mellowed down by time and weather, into objects delightful to the painter's eye, and congenial subjects for his pencil. Dilapidation, or something approaching to it, and touches of lichenous vegetable incrustation, are almost indispensable to qualify a cottage for obtaining an artist's interest and vote. Nor must paucity and smallness of apertures be forgotten. Yet all these *beauties*, and many others not here enumerated, are only so many defects in the eyes of many well-meaning, but prosaic and anti-picturesque people. In fact, a cottage *to look at*, and a cottage *to live in*, are two quite distinct things: the former requires all that constitute so many defects in the latter, and *vice versâ*. While your philanthropist would have no such things as rags in the world, the artist, on the contrary, insists upon them; not, indeed, for himself, if he can possibly help it, but rags he must and will have for his beggars and gipsies. And so is it with regard to cottages. I was speaking the other day to an artist friend of mine on the subject, and the schemes for improving labourers' cottages *secundum artem*. Shorn of sundry emphatic words, that may as well be here omitted, one of his observations was: "At this rate, we shall not have a decently down-falling-looking old tenement, nor a properly beggarly hovel in all England." It was to very little purpose, I observed, that painters might draw upon their imagination for cottages, as they now do for a good many other things, cherubim included. So far from being consoled by the comfort I held out to him, he seemed rather nettled at my remark.

VII. No doubt, cottages may be built so as to be exceedingly convenient and comfortable within, and at the same time sufficiently picturesque in external appearance—at least when Time shall have done his part to them,—until when, they would be apt to look as if they had just been unpacked and taken out of bandboxes. Moreover, they would be comparatively expensive affairs; not perhaps quite so costly as royal cottages, but more so than suits the purses or else the parsimony of the devotees to the picturesque. There are bargain-hunters even in matters architectural,—people who want things both cheap and tasty, but who generally find out in the end that by the change of a *t* into an *n*, they have got hold of what is termed the "cheap and nasty." It is, indeed, possible to produce tasteful and striking effect with comparatively little or no money cost. Nevertheless, such effect costs something; if nothing, or next to nothing, to the employers, it costs architects a very great deal,—nothing less than a life of study, and infinitely more study than many make to suffice for a whole life-time. Let me not be understood as saying, that comfortableness, convenience, and other more directly utilitarian than poetic or sentimental matters, ought at all to be interfered with for the sake of ensuring picture-like appearance. But I do contend that small dwellings, built with regard both to such comfortableness, and to strict economy in point of cost, can never be beautiful objects in any sense of the term, unless beauty and homeliness be one and the same thing. Neither are they likely ever to become even picturesque,—because what will render a mere hovel so, causes them to appear only *tristefully* squalid, and equally offensive to feeling and to taste. No one has yet discovered the way of making "a silk purse out of a sow's ear." You may, indeed, tie a silk purse to it, and one well filled with gold: and so may you trick out a cottage with much that shall be from the very first highly pleasing, on account of its being studiedly elegant and tasteful; but then it will be an expensive affair—at any rate, comparatively expensive, because if effect is to be attended to and produced, there must be a good deal more or less beyond what mere necessity would dictate. Besides which, even if cost be not at all regarded, there is very great danger of a building of the kind, when intended partly as an ornamental object, turning out a very finical-looking one. He who is a mere architect, is not capable of treating such subjects properly: in order to do so, he must have more of the artist in him than falls to the share of architects in general,—or, instead of the *artistic* or artistic-picturesque, he will only give us the *artificial*. Was ever painter so smitten by what may be called an architectural tricked-out *comme-il-faut* and *secundum artem* design, as to venture to introduce it into a picture? As soon would he think of peopling a landscape with the satin-slippered and silk-stockinged peasants of the Opera-house, instead of the vulgar worsted-stocking, or perhaps stockingless, creatures of real life,—whether in the land of John Bull, or any other. Cottages that are really and positively picturesque, are those erected by people who never thought of the picturesque, or perhaps even never heard of such word. If it should be asked what it is then that has rendered them picturesque, I answer, Accident, and all that causes builders, surveyors, appraisers, and auctioneers to shake their heads at them, as if there was anything in them—I mean in their own heads.

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## ARCHITECTURE AT THE ROYAL ACADEMY;

### AND THE ARCHITECTURAL DRAWINGS AT THE EXHIBITION.

Since our preceding publication, matters look more and more cheering—riper for reform, and indicating the necessity for it. The *Art-Journal* scruples not to tell its readers very bluntly that architectural drawings have no business to be in the Exhibition. The editor seems to have made up his mind that there could not possibly be two opinions as to the propriety of excluding them altogether; and, to say the truth, they might almost as well be so, as experience the scurvy treatment they now do. As to the ill-will which he manifests towards architecture, we will merely say, that it is not exactly *the thing* for a gentleman to do who conducts an art-journal, and who professes to watch over the interests of art in all its branches,—and some of the lowest of them he takes under his especial patronage: much good may it do them. Considering the quarter it comes from, we are not at all surprised at the ill-will just instanced; but surprised we are, and that in no small degree, at an outrageous instance of similar feeling on the part of the Royal Academy. As the fact has been publicly noticed and animadverted upon by others, our readers will probably have guessed that we allude to a model of Miss Burdett Coutts's church having been sent in by its architect, Mr. Ferrey, and turned away! No wonder, therefore, that there is nothing of the kind in this season's exhibition. If there were any other productions of the same class that met with the same fate, we cannot say: it is just as probable as not that there were at least some; yet, whether such were the case makes no difference as to the *animus* displayed by the Academy. Had more models been sent in than could possibly be accommodated, some of them must, of course, have been excluded. But to reject while there was room—not to suffer so much as a single one to appear in the Exhibition, was really too bad, and showed singular want of tact also. If the Academy were determined not to admit models, they ought at least to have said as much in their advertisements to those who intended to exhibit. That would, at any rate, have been acting straightforwardly. They might have been well aware, that although models actually exhibited might fail to obtain notice, the entire absence of them would excite remark. Had none been sent, whatever remark had been made could not affect them, because they cannot compel persons to exhibit. But to act as they have done is nothing less than a solemn blunder, it being certain to lead to explanations and comments that are not at all to the honour of the Academy. If the painters are ashamed of having architecture in their company, let them honestly and openly declare as much, instead of resorting to every sort of mean and dirty trickery in order to force it out. If the Academy can shift without architecture, the latter can shift equally well without the Academy, there being, most luckily, another royal, and eminently public-spirited body, which only waits for architecture being dismissed from the Academy, to bring it more effectively before the public. Nothing—so we are assured—but delicacy towards the Academy, has withheld the Institute from getting up an annual exhibition of architectural designs of every class, upon an adequate scale. Well, they need not now be restrained by delicacy, for it would be entirely thrown away after the "exhibition" of the cloven-foot in their conduct towards architecture.

For our part, we are not at all sorry that the Academy have acted as they have done, because they now leave no room for doubting of their hostility towards architecture. They have now fairly committed themselves; and if architects should not now be stirred up to resent the insults put upon their art, and upon themselves as a professional body, they will richly deserve to be treated with ignominy and scorn. We would fain be of better hope. We

trust that not only they will properly resent it, but that the Professor of Architecture himself will now rouse himself from his lethargy, and stand up for the honour and the interests of his own art. If he do not do so, the sooner he has a successor the better; for even should it be "Mr. Pecksniff" himself, he cannot possibly do less, and might probably do a little more. Mr. Cockerell is, we have no doubt, a very well-meaning gentleman, and sufficiently well qualified to discharge the duties of his office, so long as difficulties do not present themselves; but he does not show himself to be the man who is both capable of and determined to meet difficulties boldly, and to exert himself energetically in behalf of that art which his professorship at the Academy points him out to the public as the representative. If he has expostulated with the Academy in regard to their treatment of architecture, he does himself very great injustice in concealing it from the world; thereby leaving it to be inferred that he is altogether indifferent to the matter.

After this *tirade*, if so it should be called, though what we have said is neither uncalled for nor unprovoked, we were going to say that we resume, and proceed with our remarks on the subjects exhibited, when, as ill luck, or at any rate luck of some sort or other, will have it, we are perforce, compelled to postpone them till our next number, when we shall lay them before our readers. In the meanwhile, we have at any rate given them something to cogitate upon, inviting those who may agree with us to support us in our opinions by expressing their own, and assuring those who may happen to dissent from them that we are quite ready and willing to receive and listen to whatever they may have to advance that shall countenance the treatment which architecture receives at the hands of that specimen of royalty—the Royal Academy!

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## COLLISION OF TRAINS.

In the following paper we propose to determine the shock experienced at any part of a railway train during a collision, and to propose methods for obviating the mischief that ensues. To simplify our ideas, let us first suppose the weights of the separate carriages all equal, and the buffers removed. Let the number of carriages be N; the impulse on the first carriage that sustains the shock R; $r_n$ the impulse between the $n$th and $\overline{n+1}$th carriage: then the velocity in all parts of the train being the same relatively, both before and after impact, the carriages being supposed inelastic, and the masses of all the carriages equal, we shall have the following equation:—

$$r_{n+2} - r_{n+1} = r_{n+1} - r_n, \text{ for all values of } n;$$
$$\text{or, } r_{n+2} - 2\,r_{n+1} + r_n = 0;$$

a linear equation of differences, the solution of which is $r_n = (Cn + C')$; but $r_0$ (the impulse on the last carriage outside) $= 0$.

$$\therefore C' = 0; \text{ and } r_N = (C\,N) = R.$$
$$\therefore C = \frac{R}{N}; \text{ and } r_n = \frac{R}{N}\,n.$$

If the masses of the carriages had been unequal, $m_n$ the mass of the $n$th carriage, we should have had N equations of the form $\frac{r_{n+2} - r_{n+1}}{m_{n+2}} = \frac{r_{n+1} - r_n}{m_{n+1}}$, from which to determine $r_n$, &c.

From this we conclude, that *in a train of equally-loaded carriages the shock increases directly as the distance of any given carriage from the end of the train farthest from the point of impact.*

The design of buffers is to diminish the violence of the shock; that is to say, to change impulse (which is intense pressure continued for a very short time) into a lesser pressure continued for a longer time; but, as we shall immediately show, it is not practically possible to construct buffers capable of thus translating the whole or any considerable part of a violent shock—such, for instance, as is experienced when an express-engine accidentally is turned into a siding upon a heavy luggage-engine. To take an example:—Let the express-engine weigh 20 tons; its rate be 40 miles an hour; the stationary luggage-engine weigh 30 tons: then, if $m$, $m'$, be the masses of the trains, $v$ the velocity of the express, and $R = \frac{v\,(m\,m')}{m + m'}$;

$v$ expressed in feet per second $= 60$ nearly;

$m = \frac{20\,(2240)}{32}$; $m' = \frac{30\,(2240)}{32}$ nearly, in masses of a lb. weight.

$\therefore$ R = nearly 50,400 units of momentum, or the momentum is the same as would be occasioned by a mass of 3,200 lb. weight impinging on a fixed obstacle at the rate of 504 feet a second.

Let us now determine the pressure on the head of a buffer which is capable of translating this shock into a continuous pressure. Let the play of the buffer be supposed 2 feet, and the thrust vary as the distance by which the rod is depressed. Let $p$ be the pressure when the rod is thrust in a distance $x$; P the pressure when the rod is thrust in a distance 1: then $p = \mathrm{P}\,x$.

At the time $t$, from the commencement of the impact, let the end of the buffer have moved forward a space $= z$; the head of the buffer has moved forward a space $= z - x$: therefore, the luggage-engine has been pushed forward a space $= z - x$. Therefore, neglecting the mass of the buffer as small compared with the masses of either of the engines, we shall have these equations (the luggage-engine being supposed without buffers):—

$$m\,\frac{d^2 z}{d\,t^2} = -\mathrm{P}\,x; \quad m'\left(\frac{d^2 z}{d\,t^2} - \frac{d^2 x}{d\,t^2}\right) = \mathrm{P}\,x.$$

Eliminating $\frac{d^2 z}{d\,t^2}$, we get $\frac{d^2 x}{d\,t^2} = -\left(\frac{\mathrm{P}}{m} + \frac{\mathrm{P}}{m'}\right) x$;

$$\left(\frac{dx}{dt}\right)^2 = \mathrm{C} - \left(\frac{\mathrm{P}}{m} + \frac{\mathrm{P}}{m'}\right) x^2 = v^2 - \left(\frac{\mathrm{P}}{m} + \frac{\mathrm{P}}{m'}\right) x^2.$$

When $x = 2$ the blow is expended, and $v^2 = 4\left(\frac{\mathrm{P}}{m} + \frac{\mathrm{P}}{m'}\right)$.

$\therefore \mathrm{P} = \frac{v^2\,(m\,m')}{4\,(m + m')} = 756{,}000$ lb.; and the greatest pressure $= \mathrm{P} \times 2 =$ twice this quantity, or 675 tons.

It is needless to say that such a buffer is purely imaginary. A far better plan would be, to have one or two carriages of *very* slight construction, and filled with any kind of soft and yielding material, at both ends of a train. There is little doubt but a contrivance of this kind would destroy entirely the effect of many shocks which, unless so counteracted, would be sufficiently violent to endanger life. In the above example, to avoid the difficulty of calculating the effect of several buffers acting at once, the case of a single engine impinging on another has been considered. But when trains are attached, it is clear that the shock will be still greater than that just calculated.

If the play of the buffers—that is, the distance through which they are capable of moving, be *extremely* small as compared with the length of the carriages, the velocity at every part of the train will be the same. Therefore, $\frac{d^2 x}{d\,t^2}$ is the same at every part; and if $\mathrm{P}_n$, $\mathrm{P}_{n-1}$, be the pressures on the $n$th carriage, arising from the buffers, $\mathrm{P}_n - \mathrm{P}_{n-1} = \mathrm{P}_{n-1} - \mathrm{P}_{n-2}$ (the weight of the carriages being supposed uniform),—and, as before, if F be the pressure on the buffer of the carriage nearest the shock,—

$\mathrm{P}_n$ will $= \frac{n\mathrm{F}}{\mathrm{N}}$.

Returning to the equation $\left(\frac{dx}{dt}\right)^2 = v^2 - \left(\frac{\mathrm{P}}{m} + \frac{\mathrm{P}}{m'}\right) x^2$,

when $\frac{dx}{dt} = 0$, and the buffer is driven as far as it will go, $v^2 = \left(\frac{\mathrm{P}}{m} + \frac{\mathrm{P}}{m'}\right) x^2$.

From this we see the great advantage of having a long play on the buffers: the pressure P will be diminished in a ratio varying as the square of the length to which the buffer plays—that is, if the length of one buffer-rod be twice the length of another, and the strength of the spring of the first be only one-fourth the strength of the spring of the last, the amount of shock destroyed by either will be the same.

The practical effect of buffers, as they are ordinarily disposed throughout a train, is to resolve so much of the impact as they cannot altogether absorb, into a series of impacts of lesse momentum; for let us consider what would happen supposing a train, the several parts of which are separated by buffers, to impinge on a fixed, immoveable obstacle. So long as the buffers are all acting, $\mathrm{P}_n = \frac{n\,\mathrm{F}}{\mathrm{N}}$; consequently, the pressure on the first pair of buffers is greater than the pressure on those behind. Let V be the velocity destroyed by the total shock, $e$V the velocity destroyed by the time the first pair of buffers has ceased to act: then a velocity $(1 - e)$. V has to be destroyed in the first carriage by

a force of impact,—for the pair of buffers behind will be still acting for some little time after the first pair have ceased to act.

Again, let $e'$V be the velocity destroyed before the second pair of buffers cease to act; then, as before, the second carriage will be suddenly brought to rest by an impact on the first carriage capable of destroying the velocity $(1-e')$.V in the second carriage. Next, the third carriage will be suddenly stopped; this, likewise, will communicate a shock to the first, though less than it communicates to the second; and so on. These shocks and motions will be somewhat varied by the resiliency of the buffer-springs, and the impulsive friction of the rails against the wheels;—this latter disturbing force we have altogether omitted, as being comparatively insignificant. On the whole, then, it appears that buffers very much diminish the intensity of a shock, although they are incapable of utterly absorbing it, supposing it to be of great intensity.

I. H. R.

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## ON STONE WALLS AND EMBANKMENTS FOR RESERVOIRS OF WATER-WORKS.

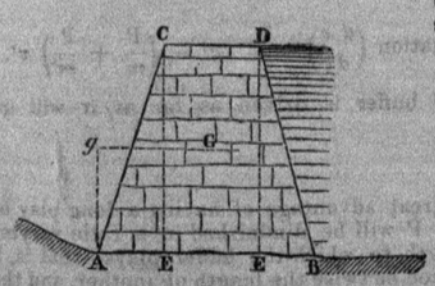
By R. G. Clark.

The intention of this paper is to treat of the pressure of water against walls and embankments of reservoirs for water-works and canals, and to lay down some easy formulæ to find the necessary dimensions so as to effectually resist the pressure of the water; the demonstration of these formulæ being effected by the simplest methods of investigation. We shall first exhibit some investigations for stone walls. The level of the surface of the water in all cases to be supposed on a level, or co-incident with the top of the wall or embankment, so as to favour the stability of the structure in case of floods or violent agitation of the water by storm winds,—although the water might be when in a quiescent state but two feet from the top. The following description of walls are required to inclose a few acres of water, when there is no suitable kind of earth to be obtained in the locality for forming an embankment. The walls are to be constructed in solid masonry, of a uniform connection in all its parts.

I. Given the height of the wall, the depth of the water being the same, and the batters on each side of the wall equal; to determine the thickness of the wall at the bottom:—

Let A B C D be a vertical section of the wall; D W the level of the water; let $x$ denote the required thickness, A B, of the wall; the batter, B F or E A, by $b$; the height of wall by $a$; the specific gravity of water by unity; and that of the material by $s$. After some reduction, we have for the equation of equilibrium,

$$\tfrac{1}{2}abx - \tfrac{1}{6}b^2a - \tfrac{1}{3}a^3 + s\mathrm{M}m = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (a);$$



Fg. 1.

(see "Moseley's Hydrostatics," Art. 51), where M = area, and $m$ horizontal distance of centre of gravity G from A; $\mathrm{M} = \tfrac{1}{2}a(2x-2b) = a(x-b)$; and $m = \tfrac{1}{2}x$; Therefore, $s\mathrm{M}m = \tfrac{1}{2}ax(x-b)s =$ moment about A; which substitute in the above general equation,

$$\text{we have } x^2 + \left(\frac{b}{s} - b\right)x = \frac{a^2+b^2}{3s} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1).$$

*Ex.* Given the height of the wall = 24 feet; batter each side, 4 feet; and the specific gravity of the material, 2: to find the thickness at bottom and top.

Here $a = 24$; $b = 4$; and $s = 2$.

Substitute these values in (1), we have $x^2 - 2x = 98{\cdot}6$;

$\therefore x = 11$ nearly $=$ A B; and C D $= 3$.

II. Let the vertical section of the wall be rectangular, or the sides vertical; to find the thickness at bottom:—

Now area A B C D $\times \tfrac{1}{2}$ distance of centre of gravity from A $= \tfrac{1}{6}a^3$

$$\therefore as\,x = \tfrac{1}{6}a^3;\quad \therefore x^2 = \frac{a^2}{3s};\quad \text{hence, } x = \frac{\sqrt{a^2}}{3s} \quad \ldots\ldots\ldots \quad (2).$$

*Ex.* Given the height of the wall = 24 feet, and the specific gravity of the material, 2: to determine A B.

$$x = \sqrt{\left(\frac{24^2}{3\times 2}\right)} = 9{\cdot}8, \text{ the thickness required.}$$

III. Let the side of the wall next the water be battered, and the side behind vertical; to determine A B, the thickness at the base.

Let A B C D be the vertical section, and let fall the perpendicular C E.

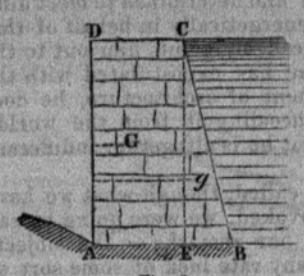


Fig. 2.

The momentum of the triangle C E B about A from its horizontal distance of centre of gravity $g$,

$$s \,.\, \tfrac{1}{2}ab \times (\tfrac{1}{3}b + x - b).$$

The momentum of rectangle D C A E about A from its centre of gravity,

$$s\,a\,(x-b) \times \tfrac{1}{2}(x-b).$$

Adding these two together, and substitute for $s$ M $m$ in equation ($a$), as in first case, we have, after transposing,

$$x^2 + \left(\frac{b}{s} - b\right)x = \frac{a^2+b^2}{3s} - \frac{1}{3}b^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3).$$

*Ex.* Given the height of wall, 24 feet; batter, 4 feet; and specific gravity of stone, 2: required the thickness of the top and bottom.

By substitution of the above values in equation (3),

we have, $x^2 - 2x = 92{\cdot}7$.

Solving this quadractic, we have $x =$ A B $= 9{\cdot}2$; top, $5{\cdot}2$.

IV. When the wall is battered behind, and the side facing the water perpendicular.

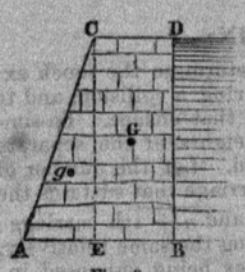


Fig. 3.

The two first terms of ($a$) vanish when B D is vertical; $\therefore s\mathrm{M}n = \tfrac{1}{6}a^3$.

The moment of triangle A E C about A, by its horizontal distance of its centre of gravity,

$$s \,.\, \tfrac{1}{2}ab \times \tfrac{2}{3}b;$$

and also of rectangle C E B D about A,

$$a\,(x-b) \times \left(b + \frac{x-b}{2}\right)s;$$

$\therefore$ substituting the sum in equation (1),

$$\text{we have } x^2 = \frac{a^2}{3s} + \frac{1}{3}b^2.$$

*Ex.* Given the dimensions of the wall as in last example; to determine the thickness at bottom:—

$$x^2 = \frac{24^2}{6} + \frac{16}{3} = 96 + 5{\cdot}3 = 101{\cdot}3;$$

$\therefore x = 10{\cdot} =$ A B; and C D $= 6{\cdot}$

For additional strength to the above walls, it would be well to insert at the centre of them one tier of bond, about two-thirds the height from the top, which will be at the centre of pressure.

V. We shall now give a case where earth shall be required in the construction of an embankment, of the form of a trapezoid, having a vertical clay puddle-wall in the middle, and the slope facing the water being paved with suitable material, with a puddle under. In case of any contraction of the clay, there would be a separation of the clay from the earth; therefore, the triangle D E B should be of sufficient strength alone to resist the fluid pressure, either against sliding or revolving on D. The water is supposed to be co-incident with the top of the embankment.

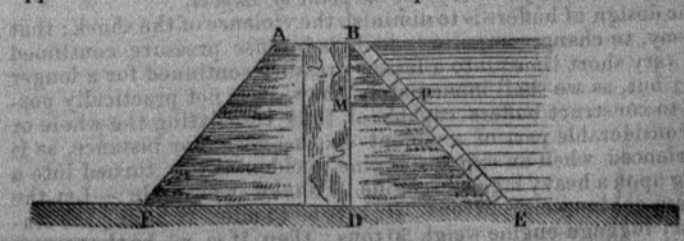


Fig. 4.

Let D B $= a$; B E $= a$. Draw P M parallel to F E; and the horizontal pressure of water = momentum B P M $\times$ horizontal distance of centre of gravity from D;

$$\therefore \frac{1}{6}x^3 = \frac{1}{2}\int s\,y^2\,dx;\quad \therefore y^2 = \frac{1}{s}x^2;\quad \therefore \mathrm{DE} = \sqrt{\left(\frac{1}{s}\right)}\,a.$$

*Ex.* Given the height of the embankment, 20 feet; specific gravity of material = 1·4 (water being unity): to determine the base D E of the triangle D E B; also the whole width of bottom, when it has a horizontal surface A B at top, 3 feet wide.

$s = 1{\cdot}4$; $BD = a$; $\therefore BE = \sqrt{\left(\frac{1}{1{\cdot}4}\right)}\,20 = 16{\cdot}8$ feet required; therefore, the whole width $FE = 36{\cdot}4$.

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## THE CIVIL SURVEYORS AND THE MILITARY SURVEYORS.

The Surveyors' Association is proceeding vigorously in its defence of the professional rights against the government usurpation, though we very much wish that they had taken this course at an earlier period, for we long since pointed out to them the course of invasion which the military employees of the government were carrying on against the public. Among the late allies of the government jobbers is our contemporary, the *Athenæum*, usually among the foremost advocates of sound and enlightened policy; and we have no other means of accounting for the remarks contained in the number of the 17th June, than by the supposition that its sympathy in the cause of sanitary reform has been taken advantage of by some of the jobbers, to foist on the editor a mis-statement of the case. It is by alarming the sanitary reformers that the jobbers hope to hide their own designs, representing that there is an attempt to prevent the sanitary plans from being carried out in the most efficient manner; whereas the same issue is pleaded against them. The *Athenæum* cannot be expected in its literary capacity to take part in all the details of engineering questions, and it is quite excusable that it should give way to the assumptions of the military engineers. We do, however, hope that the editor will re-consider the case, and not give the weight of his advocacy to a course of policy which is eminently calculated to retard the progress of sanitary reform.

At the present day, there is an assumption on the part of the government functionaries, that it is the government which has effected the great sanitary reforms already made, and that none but government functionaries can carry them out; whereas, the whole statement is utterly untrue. The great improvements in sewage were made by the exertions of members of the engineering profession, before the government had any share in the administration; and the plans now being carried out are those emanating from the officers of the old commissions. What the government is answerable for, is—first, neglect, in allowing the old irresponsible commissions to exist; and second, usurpation, in assuming the administration of the sewers to a new set of irresponsible commissioners, instead of establishing representative commissioners. The government parties make a great fuss about the new era of sanitary reform, with which they have as much to do as a cuckoo has with the construction of a sparrow's nest; the new era of sanitary reform, and the new lights on sewage engineering, having emanated not from government, but from Messrs. Roe and Phillips, who originated the present cheap and efficient plans, and carried them into practical execution. So, similarly, the plans for the supply of water by constant service did not emanate from the government, but from the hydraulic engineers. Hitherto, all that has been done in sanitary engineering, as in every other department of engineering, which has been done efficiently, has been done by the civil engineers, and not by the government engineers; and it never can be done efficiently except by the civil engineers. For this reason alone, we should view with jealousy any attempt to supersede the civil engineers.

The *Athenæum* has given faith to the assumption that the military engineers have a superiority in their professional capacity, whereas the issue is not whether they have a superiority, but whether they have an equality. Wherever the military engineers have been put to the test, they are found most inefficient; their engineering works in Canada and the colonies are far from creditable to them, or satisfactory to the nation; their volume of scientific papers is principally the production of civilians, or on civil works; and their surveys hitherto, although they cannot be subjected to any rigid test, have nevertheless been attended with serious disappointments. In the engineering world, the military engineers have no professional standing or reputation.

The *Athenæum* does not seem to be aware that we have in London, engineers competent 'to conduct a trigonometrical survey, which involves the nicest points of astronomy, and requires all the resources of mathematical analysis,'—when a reference to the Institution of Civil Engineers is quite sufficient to show the mathematical capabilities of its members; and if the *Athenæum* had adverted to the evidence as to this, given from time to time in its own columns, it would not have had any difficulty in saying who were competent to conduct the survey. If, however, the military engineers are under a slur in their professional capacity, it must be recollected that such as they are, they are not the parties who carry out all the details of the survey, which are done by the body of privates, many of whom are got from hedge-schools in Ireland. If the *Athenæum* had been aware of this, it would not have spoken of the inferior attainments and little experience of a great many of the lower surveyors—the worst of whom are, we believe, some of the best men of the government corps, who leave it as soon as they learn something, and set up for themselves. Even in the operations which are going on, hardly an officer is to be seen in the streets, but the duty is left to the privates. Mr. Bidder, Mr. Gregory, Mr. Simms, Mr. Barlow, or Mr. Buck, is not needed to perform the lower operations of a survey, which will certainly be as well performed by the repudiated surveyors as by the government corporals and privates. With regard to Mr. Edwin Chadwick's statement, that one of the associated surveyors was five years ago a journeyman carpenter, we cannot see what that has to do with the question, unless he states how many of the assistants on the government survey were journeymen bricklayers or clodhoppers five years ago, or what impediment his own former occupations are to his proficiency in sanitary science.

We join issue as to the competency of the government engineers, and as to their merits in comparison with the civil engineers. We join issue, likewise, on the point of cheapness. Mr. Chadwick knows very well, that in any comparison of cost, the general charges of the body of military engineers must be added to the special estimates. If he were not trying to uphold a job, he would not quibble upon it. We are, however, most surprised, that after the declaration in the House of Commons, the government have determined to put the country to an expense for this military survey, while the progress of the ordnance survey will be impeded.

The *Athenæum* has been likewise misled upon the point that the case of the surveyors has been decided by a competent and impartial court; whereas, the decision as yet has been an approval of Mr. Edwin Chadwick's scheme, by Mr. Edwin Chadwick's own board,—and this is what the associated surveyors are trying to upset; for they consider, in common with the great body of the profession, that they have not yet got "a hearing," and they are now "trying for a hearing," in which we hope they will be supported by the *Athenæum*, which would not, we believe, have countenanced Mr. Edwin Chadwick's plans if it had been informed of the whole truth of the case.

The *Athenæum* boldly says, that "as the nation builds its own ships, bores its own cannon, and does all things else which can be done with its own workmen, why should it not make its own surveys?" We answer, that the government has ships and machinery made elsewhere, cannon cast elsewhere, and many other things made elsewhere; and that, on the other hand, whatever is done by the government, is neither done well nor cheaply. The ordnance works, the dockyards, the post-office, and the mint, would be a disgrace to any merchant or partnership or joint-stock company. In the present case, the military surveyors have quite enough to do in the north of England, where they are wanted to finish the ordnance *un*-survey.

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*Import and Export of Metals.*—It appears from the return of the imports and exports of lead, copper, tin, and zinc, ordered by the House of Commons, that the total quantity of lead ore imported was 507 tons, of which 400 tons were from France, and the remainder principally from New South Wales. Pig and sheet lead imported amounted to 3,932 tons, of which 216 tons only were retained for home consumption—the rest being re-exported. Of British lead there were exported 8,259 tons, of which France took 1,765 tons; Russia, 1,754 tons; East Indies, 1,055 tons; and Holland, 806 tons. —The total quantity of foreign copper ore imported was 41,490 tons, of which 23,831 tons were from Cuba—the quantity of fine copper contained therein being 8,920 tons. The quantity of metallic copper imported was 513 tons; retained for home consumption, 70 tons. The quantity of copper exported was 15,142 tons.—The total quantity of tin imported was 1,165 tons, of which 161 tons were retained for home consumption; and the exports were 1,741 tons British, and 547 foreign.—The total quantity of zinc imported was 12,769 tons; and exported 886 tons British, and 3346 tons foreign.

## NOTES ON ENGINEERING.—No. IX.

By Homersham Cox, B.A.

*Synoptic Tables for calculation of Earthworks in Level and Sidelong Ground on Railways.*

No earthwork tables have hitherto been published for the express purpose of facilitating calculations for SIDELONG GROUND. The present is an effort to supply this want, which is much felt on account of the number and complexity of the operations usually required for adapting the published tables to the cases referred to. According to the existing methods, it is necessary when the ground slopes laterally, to calculate the areas of the sections, and extract the square root previously to reference to the tables. By the method here proposed, these antecedent calculations are wholly avoided: the numbers are taken from the table without any previous computation, and require only to be multiplied by the natural and artificial slopes.

The tables are also easily applicable in calculation for LEVEL GROUND; and it is believed that for both purposes the methods will be found very simple and expeditious. The tabular numbers are calculated *for every half foot*. When greater exactness is necessary, the calculator is referred to the admirable tables of Mr. Bashforth. The manuscript computations for those tables have been kindly placed at the disposal of the present writer, and have enabled him to check the accuracy of a great part of his own results.

It is not intended to demonstrate at length the formula of computation, as they depend on well-known theorems: the following brief account of them is sufficient for the present purpose.

Let A C D B be a section in a railway cutting in *level* ground, C D being the formation level, and A C, B D, the artificial slopes. As A B is horizontal, the points A, E, and B, are all at the same

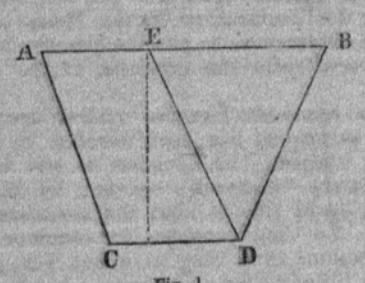


Fig. 1.

vertical height above the formation level: call this height $a$, measured in feet.

Let a similar section be taken at a distance along the railway of 66 feet, or one chain from the above, and let the vertical height there be $b$ feet. The solid content in cubic yards of the solid terminating in E D B, is $\frac{22}{27}(a^2 + ab + b^2)r$.

The solid content is $\frac{11}{9}arw$; $r$ being the "slope" of the embankments, the measurement of which will be explained more fully presently; $w$ the width in feet of the formation level.

Next, let A C D B be a section in sidelong ground—that is, ground inclined laterally or transversely to the railway. Here

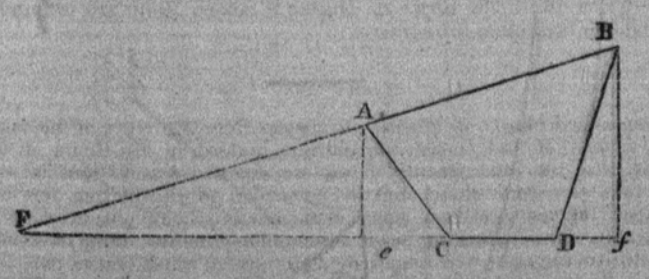


Fig. 2.

there are two sets of heights to be considered—those on the right hand, and those on the left hand of the railway: and there are two "slopes"—that of the natural ground depending on the inclination of A B; and that of the artificial embankment, depending on the inclination of either A C or B D. Call the natural slope R, and the artificial slope (as before) $r$. If $a$ and A be the heights (in feet) of the points A and B respectively, above the formation level C D, the area of the triangle A F C $= \frac{1}{2}(R + r)a^2$; and of the triangle B F D $= \frac{1}{2}(R - r)A^2$.

Similarly, if another section be taken at a distance 66 feet along the railway, and $b$, B, be the corresponding heights, the areas of the two triangles similar and similarly situated to A F C, B F D, respectively, are $\frac{1}{2}(R + r)b^2$; and $\frac{1}{2}(R - r)B^2$.

The solid content (in cubic yards) of the solid terminating in A F C $= (R + r)\frac{11}{27}(A^2 + AB + B^2)$.

The larger of the accompanying tables gives values, or $\frac{11}{27}(a^2 + ab + b^2)$, for every half foot of the two heights, up to 50 and 60 feet, respectively. The smaller table gives values of $\frac{11}{9}a \times$ by various widths of the formation level.

### METHODS OF USING THE TABLES.

*For Level-lying Ground.*—Multiply the tabular number in the larger table corresponding to the heights of two successive sections a chain apart, by twice the slope, and add the number from the smaller table, corresponding to each height separately. The result is the number of cubic yards required. For instance, let the heights be 29½ feet and 45 feet; the base, 30 feet; and the slope 2 (to one). In the larger table, the number corresponding to {29½, 45} is 1710. This, multiplied by twice the slope = 6840. Add, from the column for base 30 in the second table, the number for 29½ (which is 1082); and also the number for 45 (which is 1650): and the total (9572) is the quantity of cubic yards required.

The following is an example of the quantities corresponding to four sections, a chain apart, the corresponding heights being 16, 20½, 30, and 44½, respectively: the base, 33 feet: the slope, 2½ (to one—consequently, all the first tabular numbers are to be multiplied by twice 2½ (or 5).

| Heights. | 1st Tab. Nos. | Multiplied by twice Slope. | 2nd Tab. Nos. to Base 33. | Sum. |
|---|---|---|---|---|
| 16 / 20½ | 398 | 1990 | 645 / 827 | 3462 |
| 20½ / 30 | 788 | 3940 | 827 / 1210 | 5977 |
| 30 / 44½ | 1717 | 8585 | 1210 / 1794 | 11589 |
| | | | *Answer* | 21028 |

When the sections are at greater or less distances than one chain apart, quantities between each two sections must be multiplied by the corresponding distances. For instance, suppose in the above example the sections had been 1½, 2, and 3 chains apart: repeating the *sums* in the last column of the above scheme, we have

| Sums. | | Distances. | | Products. |
|---|---|---|---|---|
| 3462 | × | 1½ | = | 5193 |
| 5977 | × | 2 | = | 11954 |
| 11589 | × | 3 | = | 34767 |
| | | | | 51914 *Ans. required.* |

*For Sidelong Ground.*—Here the larger table alone is used. There are two sets of heights, those on the right-hand side of the railway, B $f$; and those on the left-hand side, A $e$ (fig. 2). *These sets are to be kept quite distinct.* Multiply the tabular numbers corresponding to the greater heights by the *difference* between the natural and artificial slopes, and the tabular numbers corresponding to the less heights by the *sum* of artificial and natural slopes: the difference between these products is the result required.

For instance, let the natural slope be 6½ (to one), and the artificial slope 1½ (to one): the sum of the slopes is 8, the difference 5. Also, let the heights be: 1st section, 20½, 10; 2nd section, 52, 30. The two major heights, 20½, 52, are taken together; and the two minor heights, 10 and 30, are taken together. The number in the table for the first pair is 1707; which, multiplied by 5, gives 8535. The height for the second pair is 529; which, multiplied by 8, gives 4232. The difference of the two products, or 4303, is the answer required.

Where the slopes remain unchanged for several successive sections, the sums of each set of the tabular numbers may be multiplied by the slopes, instead of multiplying each tabular number separately. For instance, let the natural slope be 3 (to one); the artificial slope, 1 (to one). Also, let the heights be, first section,

35, 10; second section, 36, 20½; third section, 39, 12; fourth section, 45, 15. The calculation is as follows:—

| Greater Heights. | Tab. Nos. | Less Heights. | Tab. Nos. |
|---|---|---|---|
| 35, 56 | 2575 | 10, 20½ | 295 |
| 56, 39 | 2787 | 20½, 12 | 330 |
| 39, 45 | 2159 | 12, 15 | 223 |
| Total | 7521 | Total | 848 |
| Mult. by diff. of slopes | 2 | Mult. by sum of slopes | 4 |
| | 15042 | | 3392 |
| Subtract | 3392 | | |
| | 11,650 *Answer.* | | |

If the sections were at unequal distances apart—say 2, 1½, 3 chains—each tabular number would have to be multiplied by the corresponding distance. The above example would then be modified as follows:—

| Tab. Nos. | Distance. | Product. | Tab. Nos. | Distance. | Product. |
|---|---|---|---|---|---|
| 2575 | × 2 = | 5150 | 295 | × 2 = | 590 |
| 2787 | × 1½ = | 3716 | 330 | × 1½ = | 440 |
| 2159 | × 3 = | 6477 | 223 | × 3 = | 669 |
| Total | | 15343 | Total | | 1699 |
| | | 2 | | | 4 |
| | | 30686 | | | 6796 |
| Subtract | | 6796 | | | |
| | | 23890 *Answer.* | | | |

*To extend the large table* where either height exceeds 60, take four times the tabular number for half the given heights. For instance, the tabular number for {100, 20} is four times that for {50, 10}.

*To extend the small table*, where either height exceeds 55, add the tabular numbers for any two heights which together make up the given height. For instance, the tabular number for 60 is the sum of the tabular numbers for 50 and 10, or of those for 55 and 5, &c.

*To find the tabular number in the greater table.* Look for *either* height in the horizontal row of index figures, and for the other height in the vertical row of indices. The tabular number required is beneath the one index and opposite the other. *In the small table* used for level-lying ground, only one index figure is used: the tabular number required is opposite it in the column designated by the given width of the formation level. For other widths than those given in the table, multiply the number to "base 1 foot" by the given width.—*Example:* The number for height 27 to base 22 is 22 × 33.

*Measurement of slopes.*—The slopes on railways are measured by the horizontal distance corresponding to one foot vertical rise. If, for instance, the rise of one foot correspond to a horizontal distance of 2½ feet, the slope is 2½ (to one). The same mode of measurement is adopted here for the natural inclination of the ground as for the artificial inclination of the sides of the embankment or cutting.

*Change of the natural slope* may occur in sidelong ground where the surface is very irregular. The sections ought to be taken so near that the difference of slopes at two successive sections may not be considerable. Now, by using exclusively the greater of these natural slopes with the actual heights, the result would be too large: by using the smaller of them, too small. But as the results obtained in these two ways will not in general widely differ, the truth may be taken as a *mean* between them.

The difficulty arising from change of natural slope may however, in general be avoided. For the upper surface of the ground being undulating and irregular, the natural inclination is represented by *equalising lines* drawn so that the small curvilinear areas in excess and defect may balance each other. These equalising lines being in some degree arbitrary in position, may in general be drawn at the same inclination for several sections together.

*** These tables, and the method of using them, are original and copyright. They are published separately by Weale, Holborn.

| | base 26ft. | base 27ft. | base 28ft. | base 29ft. | base 30ft. | base 31ft. | base 32ft. | base 33ft. | base 34ft. | base 1 ft. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 32 | 33 | 34 | 35 | 37 | 38 | 39 | 40 | 41 | 1·22 |
| ½ | 48 | 49 | 51 | 53 | 55 | 56 | 58 | 60 | 62 | 1·83 |
| 2 | 64 | 66 | 68 | 70 | 73 | 75 | 78 | 80 | 82 | 2·44 |
| ½ | 80 | 82 | 85 | 88 | 92 | 94 | 97 | 100 | 103 | 3·05 |
| 3 | 96 | 99 | 103 | 106 | 110 | 113 | 117 | 121 | 124 | 3·66 |
| ½ | 112 | 115 | 120 | 124 | 128 | 132 | 137 | 141 | 145 | 4·27 |
| 4 | 128 | 132 | 137 | 142 | 146 | 151 | 157 | 161 | 166 | 4·88 |
| ½ | 143 | 148 | 154 | 159 | 165 | 170 | 176 | 182 | 187 | 5·50 |
| 5 | 159 | 165 | 171 | 177 | 183 | 189 | 195 | 202 | 208 | 6·11 |
| ½ | 175 | 181 | 188 | 195 | 202 | 208 | 215 | 222 | 229 | 6·72 |
| 6 | 191 | 198 | 205 | 212 | 220 | 227 | 234 | 242 | 249 | 7·33 |
| ½ | 207 | 214 | 222 | 230 | 238 | 246 | 254 | 262 | 270 | 7·94 |
| 7 | 223 | 231 | 239 | 249 | 257 | 265 | 274 | 282 | 291 | 8·55 |
| ½ | 239 | 247 | 256 | 265 | 275 | 284 | 293 | 303 | 312 | 9·16 |
| 8 | 255 | 264 | 274 | 283 | 293 | 303 | 313 | 323 | 333 | 9·77 |
| ½ | 270 | 280 | 291 | 301 | 311 | 322 | 332 | 343 | 353 | 10·38 |
| 9 | 286 | 297 | 308 | 319 | 330 | 341 | 352 | 363 | 374 | 11·00 |
| ½ | 302 | 313 | 325 | 336 | 348 | 360 | 371 | 383 | 394 | 11·61 |
| 10 | 318 | 330 | 342 | 354 | 367 | 379 | 391 | 403 | 415 | 12·22 |
| ½ | 334 | 346 | 359 | 372 | 385 | 398 | 410 | 424 | 436 | 12·83 |
| 11 | 350 | 363 | 376 | 389 | 403 | 417 | 430 | 444 | 457 | 13·44 |
| ½ | 366 | 379 | 393 | 407 | 422 | 436 | 450 | 464 | 478 | 14·05 |
| 12 | 382 | 396 | 411 | 425 | 440 | 455 | 469 | 484 | 499 | 14·66 |
| ½ | 398 | 412 | 428 | 443 | 458 | 474 | 488 | 504 | 519 | 15·27 |
| 13 | 414 | 429 | 445 | 461 | 476 | 493 | 508 | 524 | 540 | 15·88 |
| ½ | 429 | 445 | 462 | 478 | 495 | 512 | 528 | 545 | 561 | 16·50 |
| 14 | 445 | 462 | 479 | 496 | 513 | 531 | 547 | 565 | 582 | 17·11 |
| ½ | 461 | 478 | 496 | 514 | 532 | 550 | 567 | 585 | 603 | 17·72 |
| 15 | 477 | 495 | 513 | 531 | 550 | 568 | 586 | 605 | 623 | 18·33 |
| ½ | 493 | 511 | 530 | 549 | 568 | 587 | 606 | 625 | 644 | 18·94 |
| 16 | 509 | 528 | 548 | 567 | 587 | 606 | 626 | 645 | 665 | 19·55 |
| ½ | 525 | 544 | 565 | 585 | 605 | 625 | 645 | 666 | 686 | 20·16 |
| 17 | 541 | 561 | 582 | 603 | 623 | 644 | 665 | 686 | 707 | 20·77 |
| ½ | 557 | 577 | 599 | 620 | 641 | 663 | 684 | 706 | 727 | 21·38 |
| 18 | 572 | 594 | 616 | 638 | 660 | 682 | 704 | 726 | 748 | 22·00 |
| ½ | 588 | 610 | 633 | 656 | 678 | 701 | 723 | 746 | 769 | 22·61 |
| 19 | 604 | 627 | 650 | 673 | 697 | 720 | 743 | 766 | 790 | 23·22 |
| ½ | 620 | 643 | 667 | 691 | 715 | 739 | 763 | 787 | 811 | 23·83 |
| 20 | 636 | 660 | 684 | 708 | 733 | 758 | 782 | 807 | 831 | 24·44 |
| ½ | 652 | 676 | 701 | 726 | 752 | 777 | 802 | 827 | 852 | 25·05 |
| 21 | 668 | 693 | 719 | 744 | 770 | 796 | 822 | 847 | 873 | 25·66 |
| ½ | 684 | 709 | 735 | 762 | 788 | 815 | 841 | 867 | 893 | 26·27 |
| 22 | 700 | 726 | 753 | 780 | 806 | 834 | 861 | 887 | 914 | 26·88 |
| ½ | 715 | 742 | 770 | 797 | 825 | 852 | 880 | 908 | 935 | 27·50 |
| 23 | 731 | 759 | 787 | 815 | 843 | 871 | 899 | 928 | 956 | 28·11 |
| ½ | 747 | 775 | 804 | 833 | 862 | 890 | 919 | 948 | 977 | 28·72 |
| 24 | 763 | 792 | 821 | 850 | 880 | 909 | 938 | 968 | 997 | 29·33 |
| ½ | 778 | 808 | 838 | 868 | 898 | 928 | 958 | 988 | 1118 | 29·94 |
| 25 | 794 | 825 | 856 | 886 | 917 | 947 | 978 | 1008 | 1039 | 30·55 |
| ½ | 810 | 841 | 873 | 904 | 935 | 966 | 997 | 1029 | 1060 | 31·16 |
| 26 | 826 | 858 | 890 | 922 | 953 | 985 | 1017 | 1049 | 1081 | 31·77 |
| ½ | 842 | 874 | 907 | 940 | 97[illegible] | 1004 | 1037 | 1069 | 1102 | 32·38 |
| 27 | 858 | 891 | 924 | 957 | 990 | 1023 | 1056 | 1089 | 1122 | 33·00 |
| ½ | 874 | 908 | 942 | 975 | 1008 | 1042 | 1076 | 1109 | 1143 | 33·61 |
| 28 | 890 | 924 | 959 | 992 | 1027 | 1061 | 1095 | 1129 | 1164 | 34·22 |
| ½ | 906 | 941 | 976 | 1010 | 1045 | 1080 | 1114 | 1149 | 1184 | 34·83 |
| 29 | 922 | 957 | 993 | 1028 | 1063 | 1099 | 1134 | 1170 | 1205 | 35·44 |
| ½ | 938 | 974 | 1010 | 1046 | 1082 | 1118 | 1154 | 1190 | 1226 | 36·05 |
| 30 | 954 | 990 | 1027 | 1063 | 1100 | 1137 | 1173 | 1210 | 1246 | 36·66 |
| ½ | 970 | 1007 | 1044 | 1081 | 1118 | 1156 | 1193 | 1230 | 1267 | 37·27 |
| 31 | 985 | 1023 | 1061 | 1098 | 1136 | 1175 | 1212 | 1250 | 1288 | 37·88 |
| ½ | 1001 | 1040 | 1078 | 1116 | 1155 | 1194 | 1232 | 1271 | 1309 | 38·50 |
| 32 | 1017 | 1056 | 1095 | 1134 | 1173 | 1213 | 1252 | 1291 | 1330 | 39·11 |
| ½ | 1033 | 1073 | 1113 | 1152 | 1192 | 1232 | 1272 | 1311 | 1351 | 39·72 |
| 33 | 1049 | 1089 | 1130 | 1169 | 1210 | 1250 | 1291 | 1331 | 1371 | 40·33 |
| ½ | 1065 | 1106 | 1147 | 1187 | 1228 | 1269 | 1310 | 1351 | 1392 | 40·94 |
| 34 | 1081 | 1122 | 1164 | 1205 | 1247 | 1288 | 1330 | 1371 | 1413 | 41·55 |
| ½ | 1097 | 1139 | 1181 | 1223 | 1265 | 1307 | 1349 | 1391 | 1433 | 42·16 |
| 35 | 1113 | 1155 | 1198 | 1240 | 1283 | 1326 | 1368 | 1411 | 1454 | 42·77 |
| ½ | 1129 | 1172 | 1215 | 1258 | 1301 | 1345 | 1388 | 1431 | 1475 | 43·38 |
| 36 | 1144 | 1188 | 1232 | 1276 | 1320 | 1364 | 1408 | 1452 | 1496 | 44·00 |
| ½ | 1160 | 1205 | 1249 | 1294 | 1338 | 1383 | 1427 | 1472 | 1516 | 44·61 |
| 37 | 1176 | 1221 | 1266 | 1312 | 1357 | 1402 | 1447 | 1492 | 1537 | 45·22 |
| ½ | 1192 | 1238 | 1283 | 1330 | 1375 | 1421 | 1467 | 1513 | 1558 | 45·83 |
| 38 | 1208 | 1254 | 1300 | 1347 | 1393 | 1440 | 1486 | 1533 | 1579 | 46·44 |
| ½ | 1224 | 1271 | 1318 | 1365 | 1412 | 1459 | 1506 | 1553 | 1600 | 47·05 |
| 39 | 1240 | 1287 | 1335 | 1382 | 1430 | 1478 | 1625 | 1573 | 1620 | 47·66 |
| ½ | 1256 | 1304 | 1352 | 1400 | 1448 | 1497 | 1645 | 1593 | 1641 | 48·27 |
| 40 | 1271 | 1320 | 1369 | 1418 | 1467 | 1516 | 1665 | 1614 | 1662 | 48·88 |
| ½ | 1287 | 1337 | 1386 | 1436 | 1485 | 1535 | 1684 | 1634 | 1683 | 49·50 |
| 41 | 1303 | 1353 | 1403 | 1453 | 1503 | 1553 | 1604 | 1654 | 1704 | 50·11 |
| ½ | 1319 | 1370 | 1420 | 1471 | 1522 | 1572 | 1623 | 1674 | 1725 | 50·72 |
| 42 | 1335 | 1386 | 1437 | 1489 | 1540 | 1591 | 1642 | 1694 | 1745 | 51·33 |
| ½ | 1351 | 1403 | 1455 | 1507 | 1558 | 1610 | 1662 | 1714 | 1766 | 51·94 |
| 43 | 1367 | 1419 | 1472 | 1524 | 1577 | 1629 | 1682 | 1734 | 1786 | 52·55 |
| ½ | 1383 | 1436 | 1489 | 1542 | 1595 | 1648 | 1701 | 1754 | 1807 | 53·26 |
| 44 | 1399 | 1452 | 1506 | 1559 | 1613 | 1667 | 1720 | 1774 | 1828 | 53·77 |
| ½ | 1415 | 1469 | 1523 | 1577 | 1631 | 1686 | 1740 | 1794 | 1849 | 54·38 |
| 45 | 1430 | 1485 | 1540 | 1595 | 1650 | 1705 | 1760 | 1815 | 1870 | 55·00 |
| ½ | 1446 | 1502 | 1557 | 1613 | 1668 | 1724 | 1779 | 1835 | 1890 | 55·61 |
| 46 | 1462 | 1518 | 1574 | 1631 | 1687 | 1743 | 1799 | 1855 | 1911 | 56·22 |
| ½ | 1478 | 1535 | 1591 | 1649 | 1705 | 1762 | 1818 | 1875 | 1932 | 56·83 |
| 47 | 1494 | 1551 | 1608 | 1666 | 1723 | 1781 | 1838 | 1895 | 1953 | 57·44 |
| ½ | 1510 | 1568 | 1626 | 1684 | 1742 | 1800 | 1858 | 1916 | 1974 | 58·05 |
| 48 | 1526 | 1584 | 1643 | 1702 | 1760 | 1819 | 1878 | 1936 | 1995 | 58·66 |
| ½ | 1542 | 1601 | 1660 | 1719 | 1778 | 1838 | 1897 | 1956 | 2015 | 59·27 |
| 49 | 1557 | 1617 | 1677 | 1737 | 1796 | 1857 | 1916 | 1976 | 2036 | 59·88 |
| ½ | 1573 | 1634 | 1694 | 1755 | 1815 | 1876 | 1936 | 1997 | 2057 | 60·50 |
| 50 | 1589 | 1650 | 1711 | 1773 | 1833 | 1894 | 1955 | 2017 | 2078 | 61·11 |
| ½ | 1605 | 1667 | 1728 | 1791 | 1852 | 1913 | 1975 | 2037 | 2099 | 61·72 |
| 51 | 1621 | 1683 | 1745 | 1809 | 1870 | 1932 | 1994 | 2057 | 2119 | 62·33 |
| ½ | 1637 | 1700 | 1763 | 1826 | 1888 | 1951 | 2014 | 2077 | 2140 | 62·94 |
| 52 | 1653 | 1716 | 1780 | 1843 | 1907 | 1970 | 2033 | 2097 | 2160 | 63·55 |
| ½ | 1669 | 1733 | 1797 | 1861 | 1925 | 1989 | 2053 | 2117 | 2181 | 64·16 |
| 53 | 1684 | 1749 | 1814 | 1879 | 1943 | 2008 | 2073 | 2138 | 2202 | 64·77 |
| ½ | 1700 | 1766 | 1831 | 1896 | 1961 | 2027 | 2092 | 2158 | 2223 | 65·38 |
| 54 | 1716 | 1782 | 1848 | 1914 | 1980 | 2046 | 2112 | 2178 | 2244 | 66·00 |
| ½ | 1732 | 1799 | 1865 | 1942 | 1998 | 2065 | 2132 | 2198 | 2265 | 66·61 |
| 55 | 1748 | 1815 | 1882 | 1960 | 2016 | 2084 | 2152 | 2218 | 2285 | 67·22 |

| | 0 | ½ | 1 | ½ | 2 | ½ | 3 | ½ | 4 | ½ | 5 | ½ | 6 | ½ | 7 | ½ | 8 | ½ | 9 | ½ | 10 | ½ | 11 | ½ | 12 | ½ | 13 | ½ | 14 | ½ | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ·5 | ·7 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 14 | 16 | 19 | 23 | 26 | 29 | 33 | 37 | 41 | 45 | 49 | 54 | 58 | 64 | 69 | 74 | 80 | 86 | 92 | 98 |
| ½ | ·9 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 14 | 16 | 19 | 22 | 25 | 28 | 31 | 35 | 39 | 45 | 47 | 52 | 57 | 62 | 67 | 72 | 77 | 84 | 89 | 96 | 102 |
| 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 13 | 16 | 18 | 21 | 24 | 27 | 30 | 34 | 38 | 42 | 46 | 56 | 55 | 60 | 65 | 70 | 75 | 81 | 87 | 93 | 99 | 106 |
| ½ | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 13 | 15 | 18 | 20 | 23 | 26 | 29 | 32 | 36 | 40 | 44 | 48 | 53 | 58 | 63 | 68 | 73 | 78 | 84 | 90 | 96 | 102 | 109 |
| 3 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 13 | 15 | 17 | 20 | 22 | 25 | 28 | 32 | 35 | 39 | 43 | 47 | 51 | 56 | 61 | 66 | 71 | 77 | 82 | 88 | 94 | 100 | 106 | 113 |
| ½ | 4 | 5 | 6 | 7 | 9 | 11 | 13 | 15 | 17 | 19 | 22 | 25 | 28 | 31 | 35 | 38 | 42 | 46 | 50 | 54 | 59 | 64 | 69 | 74 | 80 | 86 | 92 | 98 | 104 | 110 | 117 |
| 4 | 6 | 7 | 8 | 9 | 11 | 13 | 15 | 17 | 19 | 22 | 25 | 28 | 31 | 34 | 38 | 41 | 45 | 49 | 54 | 58 | 63 | 68 | 73 | 78 | 84 | 90 | 96 | 102 | 109 | 115 | 122 |
| ½ | 8 | 9 | 10 | 11 | 13 | 15 | 17 | 19 | 22 | 25 | 27 | 30 | 34 | 37 | 41 | 44 | 48 | 52 | 57 | 62 | 67 | 72 | 77 | 82 | 88 | 94 | 101 | 107 | 113 | 120 | 127 |
| 5 | 10 | 11 | 12 | 14 | 16 | 18 | 20 | 22 | 25 | 27 | 30 | 33 | 37 | 40 | 44 | 48 | 52 | 56 | 61 | 66 | 71 | 76 | 82 | 87 | 93 | 99 | 106 | 112 | 118 | 125 | 132 |
| ½ | 12 | 13 | 14 | 16 | 18 | 20 | 22 | 25 | 28 | 30 | 33 | 36 | 40 | 43 | 47 | 51 | 56 | 60 | 65 | 70 | 75 | 80 | 86 | 91 | 97 | 103 | 110 | 116 | 123 | 129 | 137 |
| 6 | 14 | 15 | 16 | 19 | 21 | 23 | 25 | 28 | 31 | 34 | 37 | 40 | 44 | 44 | 51 | 55 | 60 | 64 | 69 | 74 | 80 | 85 | 91 | 96 | 102 | 107 | 115 | 121 | 128 | 134 | 143 |
| ½ | 17 | 18 | 19 | 22 | 24 | 26 | 28 | 31 | 34 | 37 | 40 | 43 | 47 | 50 | 55 | 59 | 64 | 69 | 73 | 78 | 84 | 89 | 95 | 101 | 108 | 113 | 120 | 126 | 133 | 140 | 148 |
| 7 | 20 | 21 | 23 | 25 | 27 | 29 | 32 | 35 | 38 | 41 | 44 | 47 | 51 | 55 | 60 | 64 | 69 | 73 | 78 | 83 | 89 | 94 | 100 | 106 | 113 | 119 | 126 | 132 | 139 | 146 | 154 |
| ½ | 23 | 24 | 26 | 28 | 30 | 32 | 35 | 38 | 41 | 44 | 48 | 51 | 55 | 59 | 64 | 69 | 73 | 78 | 83 | 88 | 94 | 99 | 105 | 111 | 118 | 124 | 131 | 138 | 145 | 152 | 160 |
| 8 | 26 | 28 | 29 | 31 | 34 | 36 | 39 | 42 | 45 | 48 | 52 | 56 | 60 | 64 | 69 | 73 | 78 | 83 | 88 | 93 | 99 | 105 | 111 | 117 | 124 | 130 | 137 | 144 | 151 | 158 | 166 |
| ½ | 29 | 31 | 33 | 35 | 38 | 40 | 43 | 46 | 49 | 52 | 56 | 60 | 64 | 69 | 73 | 78 | 83 | 88 | 93 | 99 | 104 | 110 | 116 | 123 | 130 | 136 | 143 | 150 | 157 | 164 | 172 |
| 9 | 32 | 34 | 37 | 39 | 42 | 44 | 47 | 50 | 54 | 57 | 61 | 65 | 69 | 73 | 78 | 83 | 88 | 93 | 99 | 104 | 110 | 116 | 122 | 129 | 136 | 142 | 149 | 156 | 164 | 171 | 179 |
| ½ | 36 | 38 | 41 | 43 | 46 | 48 | 51 | 54 | 58 | 62 | 66 | 70 | 74 | 78 | 83 | 88 | 93 | 99 | 104 | 110 | 116 | 122 | 128 | 135 | 142 | 148 | 155 | 162 | 170 | 178 | 186 |
| 10 | 40 | 42 | 45 | 47 | 50 | 53 | 56 | 59 | 63 | 67 | 71 | 75 | 80 | 84 | 89 | 94 | 99 | 104 | 110 | 116 | 122 | 128 | 135 | 141 | 148 | 155 | 162 | 169 | 177 | 184 | 193 |
| ½ | 44 | 46 | 49 | 52 | 55 | 58 | 61 | 64 | 68 | 72 | 76 | 80 | 85 | 89 | 94 | 99 | 105 | 110 | 116 | 122 | 128 | 135 | 141 | 147 | 154 | 161 | 169 | 176 | 184 | 192 | 200 |
| 11 | 49 | 51 | 54 | 57 | 60 | 63 | 66 | 69 | 73 | 77 | 82 | 86 | 91 | 95 | 100 | 105 | 111 | 116 | 122 | 128 | 135 | 141 | 148 | 154 | 161 | 168 | 176 | 184 | 192 | 200 | 208 |
| ½ | 54 | 56 | 58 | 62 | 65 | 68 | 71 | 74 | 78 | 82 | 87 | 91 | 96 | 101 | 106 | 111 | 117 | 123 | 129 | 135 | 141 | 147 | 154 | 161 | 168 | 176 | 183 | 191 | 199 | 207 | 215 |
| 12 | 58 | 61 | 64 | 67 | 70 | 73 | 77 | 80 | 84 | 88 | 93 | 97 | 102 | 107 | 113 | 118 | 124 | 130 | 136 | 142 | 148 | 154 | 161 | 168 | 176 | 183 | 191 | 199 | 207 | 215 | 223 |
| ½ | 63 | 68 | 69 | 72 | 75 | 78 | 82 | 86 | 90 | 94 | 99 | 103 | 108 | 113 | 119 | 124 | 130 | 136 | 142 | 148 | 155 | 161 | 168 | 176 | 183 | 190 | 198 | 206 | 215 | 223 | 231 |
| 13 | 69 | 71 | 74 | 77 | 81 | 84 | 88 | 92 | 96 | 101 | 106 | 110 | 115 | 120 | 126 | 131 | 137 | 143 | 149 | 155 | 162 | 169 | 176 | 183 | 191 | 198 | 206 | 214 | 223 | 231 | 240 |
| ½ | 74 | 77 | 80 | 83 | 87 | 90 | 94 | 98 | 102 | 107 | 112 | 116 | 121 | 126 | 132 | 138 | 144 | 150 | 156 | 162 | 169 | 176 | 184 | 191 | 199 | 206 | 214 | 223 | 231 | 240 | 248 |
| 14 | 80 | 83 | 86 | 89 | 93 | 96 | 100 | 104 | 109 | 113 | 118 | 123 | 128 | 133 | 139 | 145 | 151 | 157 | 164 | 170 | 177 | 184 | 192 | 199 | 207 | 215 | 223 | 231 | 239 | 248 | 257 |
| ½ | 86 | 89 | 92 | 96 | 99 | 102 | 106 | 110 | 115 | 120 | 125 | 129 | 134 | 140 | 146 | 152 | 158 | 164 | 171 | 178 | 184 | 192 | 200 | 207 | 215 | 223 | 231 | 240 | 248 | 257 | 266 |
| 15 | 91 | 95 | 98 | 102 | 106 | 109 | 113 | 117 | 122 | 127 | 132 | 137 | 143 | 148 | 154 | 160 | 166 | 172 | 179 | 186 | 193 | 200 | 208 | 215 | 223 | 231 | 241 | 248 | 257 | 266 | 275 |
| ½ | 98 | 111 | 104 | 109 | 112 | 116 | 120 | 124 | 129 | 134 | 139 | 144 | 150 | 156 | 162 | 168 | 174 | 180 | 187 | 194 | 201 | 209 | 216 | 224 | 232 | 240 | 249 | 257 | 266 | 275 | 284 |
| 16 | 104 | 107 | 111 | 115 | 119 | 123 | 127 | 132 | 137 | 142 | 147 | 152 | 158 | 164 | 170 | 176 | 182 | 189 | 196 | 203 | 210 | 217 | 225 | 233 | 241 | 249 | 258 | 266 | 275 | 284 | 293 |
| ½ | 110 | 114 | 118 | 122 | 126 | 130 | 134 | 139 | 144 | 149 | 154 | 160 | 166 | 172 | 178 | 184 | 190 | 197 | 204 | 211 | 218 | 226 | 234 | 242 | 250 | 258 | 267 | 275 | 284 | 293 | 303 |
| 17 | 117 | 121 | 125 | 129 | 133 | 137 | 142 | 147 | 152 | 157 | 162 | 168 | 174 | 180 | 186 | 192 | 199 | 206 | 213 | 220 | 227 | 235 | 243 | 251 | 259 | 267 | 276 | 285 | 294 | 303 | 313 |
| ½ | 124 | 128 | 132 | 136 | 140 | 144 | 149 | 154 | 160 | 165 | 170 | 176 | 182 | 188 | 194 | 200 | 207 | 214 | 222 | 229 | 236 | 244 | 252 | 260 | 268 | 277 | 286 | 295 | 304 | 313 | 323 |
| 18 | 132 | 135 | 139 | 143 | 148 | 152 | 157 | 162 | 168 | 173 | 179 | 184 | 190 | 196 | 203 | 209 | 216 | 223 | 231 | 238 | 246 | 254 | 262 | 270 | 278 | 287 | 296 | 305 | 314 | 323 | 333 |
| ½ | 139 | 142 | 147 | 151 | 156 | 160 | 165 | 170 | 176 | 181 | 187 | 193 | 199 | 205 | 212 | 218 | 225 | 232 | 240 | 247 | 255 | 263 | 271 | 279 | 288 | 297 | 306 | 315 | 324 | 334 | 344 |
| 19 | 147 | 151 | 155 | 159 | 164 | 169 | 174 | 179 | 184 | 190 | 196 | 202 | 208 | 214 | 221 | 228 | 235 | 242 | 249 | 257 | 265 | 273 | 281 | 289 | 298 | 307 | 316 | 325 | 335 | 345 | 355 |
| ½ | 155 | 158 | 163 | 167 | 172 | 177 | 182 | 187 | 193 | 199 | 205 | 211 | 217 | 223 | 230 | 237 | 244 | 251 | 259 | 267 | 275 | 282 | 291 | 299 | 309 | 317 | 326 | 336 | 346 | 356 | 366 |
| 20 | 163 | 167 | 171 | 176 | 181 | 186 | 191 | 196 | 202 | 208 | 214 | 220 | 226 | 233 | 240 | 247 | 254 | 261 | 269 | 277 | 285 | 293 | 302 | 310 | 319 | 328 | 337 | 347 | 357 | 367 | 377 |
| ½ | 171 | 175 | 179 | 184 | 189 | 194 | 200 | 205 | 211 | 217 | 223 | 229 | 235 | 242 | 249 | 256 | 264 | 271 | 279 | 287 | 295 | 303 | 312 | 321 | 330 | 339 | 348 | 358 | 368 | 378 | 388 |
| 21 | 179 | 183 | 188 | 193 | 198 | 203 | 209 | 214 | 220 | 226 | 232 | 238 | 245 | 252 | 259 | 266 | 274 | 281 | 289 | 297 | 306 | 314 | 323 | 332 | 341 | 350 | 359 | 369 | 379 | 389 | 399 |
| ½ | 188 | 192 | 197 | 202 | 207 | 212 | 218 | 223 | 229 | 235 | 242 | 248 | 255 | 262 | 269 | 276 | 284 | 292 | 300 | 308 | 316 | 325 | 334 | 343 | 352 | 361 | 371 | 381 | 391 | 401 | 411 |
| 22 | 197 | 201 | 206 | 211 | 216 | 221 | 227 | 233 | 239 | 245 | 252 | 258 | 265 | 272 | 280 | 287 | 295 | 303 | 311 | 319 | 327 | 336 | 345 | 354 | 363 | 372 | 382 | 392 | 402 | 412 | 423 |
| ½ | 206 | 210 | 215 | 220 | 226 | 231 | 237 | 243 | 249 | 255 | 262 | 268 | 275 | 282 | 290 | 297 | 305 | 313 | 322 | 330 | 338 | 347 | 356 | 365 | 374 | 384 | 394 | 404 | 414 | 424 | 435 |
| 23 | 215 | 220 | 225 | 230 | 236 | 241 | 247 | 253 | 259 | 265 | 272 | 279 | 286 | 293 | 301 | 308 | 316 | 324 | 333 | 341 | 350 | 359 | 368 | 377 | 386 | 396 | 406 | 416 | 426 | 436 | 447 |
| ½ | 224 | 229 | 235 | 240 | 246 | 251 | 257 | 263 | 269 | 275 | 282 | 289 | 297 | 304 | 312 | 319 | 327 | 336 | 344 | 353 | 361 | 370 | 379 | 388 | 398 | 408 | 418 | 428 | 438 | 448 | 460 |
| 24 | 234 | 239 | 245 | 250 | 256 | 261 | 267 | 273 | 280 | 286 | 293 | 300 | 308 | 315 | 323 | 331 | 339 | 347 | 355 | 364 | 373 | 382 | 391 | 400 | 410 | 420 | 430 | 440 | 451 | 461 | 473 |
| ½ | 244 | 249 | 255 | 260 | 266 | 271 | 278 | 288 | 291 | 297 | 304 | 311 | 319 | 326 | 334 | 342 | 350 | 358 | 367 | 376 | 385 | 394 | 403 | 412 | 422 | 432 | 443 | 453 | 464 | 474 | 486 |
| 25 | 254 | 259 | 265 | 270 | 276 | 281 | 289 | 296 | 302 | 308 | 315 | 322 | 330 | 338 | 346 | 354 | 362 | 370 | 379 | 388 | 397 | 406 | 416 | 425 | 435 | 445 | 456 | 466 | 477 | 488 | 499 |
| ½ | 264 | 269 | 275 | 281 | 287 | 293 | 300 | 306 | 313 | 320 | 326 | 333 | 341 | 349 | 357 | 365 | 373 | 381 | 390 | 399 | 409 | 418 | 428 | 438 | 448 | 458 | 469 | 479 | 490 | 501 | 512 |
| 26 | 275 | 280 | 286 | 292 | 298 | 304 | 311 | 317 | 324 | 331 | 338 | 345 | 353 | 361 | 369 | 377 | 386 | 394 | 403 | 412 | 422 | 431 | 441 | 451 | 461 | 471 | 482 | 492 | 508 | 514 | 526 |
| ½ | 286 | 291 | 297 | 303 | 309 | 315 | 323 | 328 | 335 | 342 | 350 | 357 | 365 | 373 | 381 | 389 | 398 | 407 | 416 | 425 | 434 | 444 | 454 | 464 | 474 | 484 | 495 | 506 | 517 | 528 | 539 |
| 27 | 297 | 302 | 308 | 314 | 320 | 326 | 333 | 340 | 347 | 354 | 362 | 369 | 377 | 385 | 394 | 402 | 411 | 420 | 429 | 438 | 447 | 457 | 467 | 477 | 487 | 498 | 509 | 520 | 531 | 542 | 553 |
| ½ | 308 | 313 | 319 | 325 | 332 | 338 | 345 | 352 | 359 | 366 | 374 | 381 | 389 | 397 | 406 | 414 | 423 | 432 | 442 | 451 | 460 | 470 | 480 | 490 | 501 | 511 | 522 | 533 | 545 | 556 | 567 |
| 28 | 319 | 325 | 331 | 337 | 344 | 350 | 357 | 364 | 371 | 378 | 386 | 394 | 402 | 410 | 419 | 427 | 436 | 445 | 455 | 464 | 474 | 484 | 494 | 504 | 515 | 525 | 536 | 547 | 559 | 570 | 582 |
| ½ | 330 | 336 | 343 | 349 | 356 | 362 | 369 | 376 | 383 | 391 | 399 | 407 | 415 | 423 | 432 | 440 | 449 | 458 | 468 | 477 | 487 | 497 | 508 | 518 | 529 | 539 | 550 | 561 | 476 | 485 | 596 |
| 29 | 342 | 348 | 355 | 361 | 368 | 374 | 381 | 388 | 396 | 404 | 412 | 420 | 428 | 436 | 445 | 454 | 463 | 472 | 482 | 491 | 501 | 511 | 522 | 532 | 543 | 554 | 565 | 576 | 588 | 599 | 611 |
| ½ | 354 | 360 | 367 | 373 | 380 | 387 | 394 | 401 | 409 | 417 | 425 | 433 | 441 | 449 | 458 | 467 | 573 | 584 | 495 | 505 | 515 | 525 | 536 | 546 | 557 | 568 | 579 | 590 | 602 | 614 | 626 |
| 30 | 367 | 373 | 379 | 385 | 392 | 399 | 407 | 414 | 422 | 430 | 438 | 446 | 454 | 463 | 472 | 481 | 490 | 499 | 509 | 519 | 529 | 539 | 550 | 561 | 572 | 583 | 594 | 605 | 617 | 629 | 641 |
| ½ | 379 | 385 | 391 | 398 | 405 | 412 | 420 | 427 | 435 | 443 | 451 | 459 | 468 | 477 | 486 | 495 | 504 | 513 | 523 | 533 | 543 | 553 | 564 | 575 | 586 | 597 | 609 | 620 | 632 | 644 | 656 |
| 31 | 392 | 398 | 404 | 411 | 418 | 425 | 433 | 440 | 448 | 456 | 465 | 473 | 482 | 491 | 500 | 509 | 518 | 527 | 538 | 548 | 558 | 568 | 579 | 590 | 601 | 612 | 624 | 636 | 648 | 660 | 672 |
| ½ | 404 | 411 | 417 | 424 | 431 | 438 | 446 | 454 | 462 | 470 | 478 | 487 | 496 | 505 | 514 | 523 | 532 | 542 | 552 | 563 | 573 | 583 | 594 | 605 | 616 | 627 | 639 | 651 | 663 | 675 | 688 |
| 32 | 417 | 424 | 430 | 437 | 445 | 452 | 460 | 468 | 476 | 484 | 492 | 501 | 510 | 519 | 528 | 537 | 547 | 557 | 567 | 577 | 588 | 598 | 610 | 621 | 632 | 643 | 655 | 667 | 679 | 691 | 704 |
| ½ | 430 | 437 | 443 | 450 | 458 | 465 | 473 | 481 | 490 | 498 | 506 | 515 | 524 | 533 | 542 | 552 | 562 | 572 | 582 | 592 | 603 | 614 | 625 | 636 | 647 | 659 | 671 | 683 | 695 | 707 | 720 |
| 33 | 443 | 450 | 457 | 464 | 472 | 479 | 487 | 495 | 504 | 512 | 521 | 530 | 539 | 548 | 557 | 567 | 577 | 587 | 597 | 608 | 619 | 630 | 641 | 652 | 668 | 675 | 687 | 699 | 711 | 724 | 737 |
| ½ | 457 | 464 | 471 | 478 | 486 | 493 | 501 | 509 | 518 | 526 | 535 | 544 | 553 | 563 | 572 | 582 | 592 | 602 | 612 | 623 | 634 | 645 | 656 | 668 | 679 | 691 | 703 | 715 | 727 | 740 | 753 |
| 34 | 471 | 478 | 485 | 492 | 500 | 508 | 516 | 524 | 533 | 541 | 550 | 559 | 568 | 578 | 588 | 598 | 608 | 618 | 628 | 639 | 650 | 661 | 672 | 684 | 696 | 708 | 720 | 732 | 744 | 757 | 770 |
| ½ | 485 | 492 | 499 | 506 | 514 | 522 | 530 | 538 | 547 | 556 | 565 | 574 | 583 | 593 | 603 | 613 | 623 | 633 | 644 | 655 | 666 | 677 | 688 | 700 | 712 | 724 | 736 | 748 | 761 | 774 | 787 |
| 35 | 499 | 506 | 513 | 521 | 529 | 537 | 545 | 553 | 562 | 571 | 580 | 589 | 599 | 609 | 619 | 629 | 639 | 649 | 660 | 671 | 682 | 693 | 705 | 717 | 729 | 741 | 753 | 765 | 778 | 791 | 804 |
| ½ | 513 | 520 | 528 | 536 | 544 | 552 | 560 | 568 | 577 | 586 | 595 | 604 | 614 | 624 | 634 | 644 | 655 | 665 | 676 | 687 | 698 | 709 | 721 | 733 | 745 | 757 | 770 | 782 | 795 | 808 | 821 |
| 36 | 528 | 535 | 543 | 551 | 559 | 567 | 575 | 584 | 593 | 602 | 611 | 620 | 630 | 640 | 650 | 660 | 671 | 682 | 693 | 704 | 715 | 726 | 738 | 750 | 762 | 774 | 787 | 800 | 813 | 826 | 839 |
| ½ | 542 | 550 | 558 | 566 | 574 | 582 | 590 | 599 | 608 | 617 | 627 | 636 | 646 | 656 | 666 | 676 | 687 | 698 | 709 | 720 | 782 | 743 | 755 | 767 | 779 | 791 | 804 | 817 | 830 | 843 | 857 |
| 37 | 557 | 565 | 573 | 581 | 589 | 597 | 606 | 615 | 624 | 633 | 643 | 653 | 663 | 673 | 683 | 693 | 704 | 715 | 726 | 737 | 749 | 761 | 773 | 785 | 797 | 809 | 822 | 835 | 848 | 861 | 875 |
| ½ | 572 | 580 | 588 | 596 | 605 | 613 | 622 | 631 | 640 | 649 | 659 | 669 | 679 | 689 | 699 | 710 | 721 | 732 | 743 | 754 | 766 | 778 | 790 | 802 | 814 | 827 | 840 | 853 | 866 | 879 | 893 |
| 38 | 588 | 596 | 604 | 613 | 621 | 629 | 638 | 647 | 656 | 666 | 676 | 686 | 696 | 706 | 716 | 727 | 738 | 749 | 760 | 772 | 784 | 796 | 808 | 820 | 832 | 845 | 858 | 871 | 885 | 898 | 912 |
| ½ | 603 | 611 | 620 | 628 | 637 | 645 | 654 | 663 | 672 | 682 | 692 | 702 | 712 | 723 | 733 | 744 | 755 | 766 | 777 | 789 | 801 | 813 | 825 | 838 | 850 | 863 | 876 | 889 | 903 | 916 | 930 |
| 39 | 619 | 627 | 636 | 644 | 653 | 662 | 671 | 680 | 689 | 699 | 709 | 719 | 729 | 740 | 751 | 762 | 773 | 784 | 795 | 807 | 819 | 831 | 843 | 856 | 869 | 872 | 895 | 908 | 927 | 935 | 949 |
| ½ | 635 | 643 | 652 | 660 | 669 | 678 | 687 | 696 | 706 | 716 | 726 | 736 | 746 | 757 | 768 | 779 | 790 | 801 | 813 | 825 | 837 | 849 | 861 | 874 | 887 | 900 | 913 | 926 | 941 | 954 | 968 |
| 40 | 652 | 660 | 668 | 677 | 686 | 695 | 704 | 713 | 723 | 733 | 743 | 753 | 764 | 775 | 786 | 797 | 808 | 819 | 831 | 843 | 855 | 867 | 880 | 833 | 906 | 919 | 932 | 946 | 965 | 974 | 988 |
| ½ | 668 | 676 | 685 | 694 | 703 | 712 | 721 | 730 | 740 | 750 | 760 | 770 | 781 | 792 | 803 | 814 | 826 | 837 | 849 | 861 | 873 | 877 | 899 | 912 | 925 | 938 | 951 | 964 | 979 | 993 | 1007 |
| 41 | 685 | 693 | 702 | 711 | 720 | 729 | 738 | 748 | 758 | 768 | 778 | 788 | 799 | 810 | 821 | 832 | 844 | 856 | 868 | 880 | 892 | 905 | 918 | 931 | 944 | 957 | 971 | 984 | 998 | 1012 | 1027 |
| ½ | 701 | 710 | 719 | 728 | 737 | 746 | 755 | 765 | 775 | 785 | 796 | 806 | 817 | 828 | 839 | 851 | 862 | 874 | 886 | 898 | 911 | 924 | 937 | 950 | 963 | 977 | 990 | 1004 | 1018 | 1032 | 1047 |
| 42 | 718 | 727 | 736 | 745 | 754 | 763 | 773 | 783 | 793 | 803 | 814 | 825 | 836 | 847 | 858 | 869 | 881 | 893 | 905 | 917 | 930 | 943 | 956 | 969 | 982 | 996 | 1010 | 1024 | 1038 | 1052 | 1067 |
| ½ | 735 | 744 | 753 | 762 | 772 | 781 | 790 | 801 | 811 | 821 | 832 | 843 | 854 | 865 | 877 | 888 | 900 | 911 | 924 | 936 | 949 | 952 | 975 | 988 | 1002 | 1016 | 1030 | 1044 | 1058 | 1072 | 1087 |
| 43 | 753 | 762 | 771 | 780 | 790 | 799 | 808 | 819 | 830 | 840 | 851 | 862 | 873 | 884 | 896 | 907 | 919 | 931 | 944 | 956 | 969 | 982 | 995 | 1008 | 1022 | 1036 | 1050 | 1064 | 1078 | 1092 | 1107 |
| ½ | 770 | 779 | 789 | 798 | 808 | 817 | 827 | 837 | 848 | 859 | 870 | 881 | 892 | 903 | 915 | 926 | 938 | 950 | 963 | 975 | 988 | 1001 | 1015 | 1028 | 1042 | 1056 | 1070 | 1084 | 1098 | 1113 | 1128 |
| 44 | 788 | 797 | 807 | 816 | 826 | 836 | 846 | 856 | 867 | 877 | 888 | 900 | 911 | 922 | 934 | 946 | 958 | 970 | 983 | 995 | 1008 | 1021 | 1035 | 1048 | 1062 | 1076 | 1090 | 1104 | 1119 | 1134 | 1149 |
| ½ | 806 | 815 | 825 | 834 | 844 | 854 | 864 | 875 | 886 | 896 | 907 | 919 | 930 | 941 | 953 | 965 | 977 | 990 | 1003 | 1015 | 1028 | 1041 | 1055 | 1068 | 1082 | 1096 | 1111 | 1125 | 1140 | 1155 | 1170 |
| 45 | 825 | 834 | 843 | 853 | 863 | 873 | 883 | 894 | 905 | 916 | 927 | 938 | 949 | 961 | 973 | 985 | 997 | 1010 | 1023 | 1036 | 1049 | 1062 | 1076 | 1089 | 1103 | 1117 | 1132 | 1146 | 1161 | 1176 | 1191 |
| ½ | 843 | 852 | 862 | 872 | 882 | 892 | 902 | 913 | 924 | 935 | 946 | 957 | 969 | 981 | 993 | 1005 | 1017 | 1030 | 1043 | 1056 | 1069 | 1082 | 1096 | 1109 | 1124 | 1138 | 1153 | 1168 | 1182 | 1197 | 1213 |
| 46 | 862 | 871 | 881 | 891 | 901 | 911 | 922 | 932 | 943 | 954 | 966 | 977 | 989 | 1001 | 1013 | 1025 | 1038 | 1050 | 1063 | 1076 | 1090 | 1103 | 1117 | 1131 | 1145 | 1159 | 1174 | 1189 | 1204 | 1219 | 1235 |
| ½ | 881 | 890 | 900 | 910 | 920 | 930 | 941 | 952 | 963 | 974 | 986 | 997 | 1009 | 1021 | 1033 | 1045 | 1058 | 1071 | 1084 | 1097 | 1111 | 1124 | 1138 | 1152 | 1166 | 1180 | 1195 | 1210 | 1226 | 1231 | 1257 |
| 47 | 900 | 909 | 919 | 929 | 940 | 959 | 961 | 972 | 983 | 994 | 1006 | 1017 | 1029 | 1041 | 1054 | 1066 | 1079 | 1092 | 1105 | 1118 | 1132 | 1146 | 1160 | 1174 | 1188 | 1202 | 1217 | 1232 | 1248 | 1263 | 1279 |
| ½ | 919 | 929 | 939 | 949 | 959 | 960 | 981 | 992 | 1003 | 1014 | 1026 | 1037 | 1049 | 1061 | 1074 | 1087 | 1100 | 1113 | 1126 | 1139 | 1153 | 1167 | 1181 | 1195 | 1210 | 1224 | 1239 | 1254 | 1270 | 1285 | 1301 |
| 48 | 938 | 948 | 958 | 969 | 979 | 980 | 1001 | 1012 | 1023 | 1034 | 1046 | 1058 | 1070 | 1082 | 1095 | 1108 | 1121 | 1134 | 1147 | 1161 | 1175 | 1189 | 1203 | 1217 | 1232 | 1246 | 1261 | 1276 | 1292 | 1307 | 1323 |
| ½ | 958 | 968 | 978 | 988 | 999 | 1010 | 1021 | 1032 | 1043 | 1045 | 1067 | 1079 | 1091 | 1103 | 1116 | 1129 | 1142 | 1155 | 1169 | 1182 | 1196 | 1210 | 1225 | 1239 | 1254 | 1269 | 1283 | 1298 | 1314 | 1330 | 1346 |
| 49 | 978 | 988 | 998 | 1008 | 1019 | 1030 | 1041 | 1052 | 1064 | 1076 | 1088 | 1100 | 1112 | 1125 | 1138 | 1141 | 1164 | 1177 | 1191 | 1204 | 1218 | 1232 | 1247 | 1261 | 1276 | 1291 | 1306 | 1321 | 1337 | 1353 | 1369 |
| ½ | 998 | 1008 | 1018 | 1029 | 1040 | 1050 | 1062 | 1073 | 1085 | 1097 | 1009 | 1121 | 1133 | 1146 | 1159 | 1172 | 1185 | 1199 | 1213 | 1226 | 1239 | 1254 | 1269 | 1283 | 1298 | 1313 | 1329 | 1344 | 1360 | 1376 | 1392 |
| 50 | 1018 | 1029 | 1039 | 1050 | 1061 | 1072 | 1083 | 1094 | 1106 | 1118 | 1130 | 1142 | 1155 | 1168 | 1181 | 1194 | 1207 | 1221 | 1235 | 1249 | 1263 | 1277 | 1292 | 1306 | 1321 | 1336 | 1352 | 1367 | 1383 | 1399 | 1415 |

| | ½ | 16 | ½ | 17 | ½ | 18 | ½ | 19 | ½ | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 104 | 111 | 117 | 125 | 132 | 139 | 146 | 155 | 162 | 171 |
| ½ | 108 | 115 | 122 | 129 | 136 | 143 | 151 | 159 | 167 | 176 |
| 2 | 112 | 119 | 126 | 133 | 140 | 148 | 156 | 164 | 172 | 181 |
| ½ | 116 | 123 | 130 | 137 | 144 | 152 | 160 | 169 | 177 | 186 |
| 3 | 120 | 127 | 134 | 142 | 149 | 157 | 165 | 174 | 182 | 191 |
| ½ | 124 | 132 | 139 | 147 | 154 | 162 | 171 | 179 | 187 | 196 |
| 4 | 129 | 137 | 144 | 152 | 160 | 168 | 176 | 184 | 193 | 202 |
| ½ | 134 | 142 | 149 | 157 | 165 | 173 | 181 | 190 | 199 | 208 |
| 5 | 139 | 147 | 154 | 162 | 170 | 179 | 187 | 196 | 205 | 214 |
| ½ | 144 | 152 | 160 | 168 | 176 | 184 | 193 | 202 | 211 | 220 |
| 6 | 150 | 158 | 166 | 174 | 182 | 190 | 199 | 208 | 217 | 226 |
| ½ | 156 | 164 | 172 | 180 | 188 | 196 | 205 | 214 | 223 | 233 |
| 7 | 162 | 170 | 178 | 186 | 194 | 203 | 212 | 221 | 230 | 240 |
| ½ | 168 | 176 | 184 | 192 | 200 | 209 | 218 | 228 | 237 | 247 |
| 8 | 174 | 182 | 190 | 199 | 207 | 216 | 225 | 235 | 244 | 254 |
| ½ | 180 | 189 | 197 | 206 | 214 | 223 | 232 | 242 | 251 | 261 |
| 9 | 187 | 196 | 204 | 213 | 222 | 231 | 240 | 249 | 259 | 269 |
| ½ | 194 | 203 | 211 | 220 | 229 | 238 | 247 | 257 | 267 | 277 |
| 10 | 201 | 210 | 218 | 227 | 236 | 246 | 255 | 265 | 275 | 285 |
| ½ | 209 | 217 | 226 | 235 | 244 | 254 | 263 | 273 | 283 | 293 |
| 11 | 216 | 225 | 234 | 243 | 252 | 262 | 271 | 281 | 291 | 302 |
| ½ | 224 | 233 | 242 | 251 | 260 | 270 | 279 | 289 | 299 | 310 |
| 12 | 232 | 241 | 250 | 259 | 268 | 278 | 288 | 298 | 308 | 319 |
| ½ | 240 | 249 | 258 | 267 | 277 | 287 | 297 | 307 | 317 | 328 |
| 13 | 249 | 258 | 267 | 276 | 286 | 296 | 306 | 316 | 326 | 337 |
| ½ | 257 | 266 | 275 | 285 | 295 | 305 | 315 | 325 | 336 | 347 |
| 14 | 266 | 275 | 284 | 294 | 304 | 314 | 324 | 335 | 346 | 357 |
| ½ | 275 | 284 | 293 | 303 | 313 | 323 | 334 | 345 | 356 | 367 |
| 15 | 284 | 293 | 303 | 313 | 323 | 333 | 344 | 355 | 366 | 377 |
| ½ | 293 | 303 | 313 | 323 | 333 | 343 | 354 | 365 | 376 | 387 |
| 16 | 303 | 313 | 323 | 333 | 343 | 353 | 364 | 375 | 386 | 397 |
| ½ | 313 | 323 | 333 | 343 | 353 | 363 | 374 | 385 | 396 | 408 |
| 17 | 323 | 333 | 343 | 353 | 363 | 374 | 385 | 396 | 407 | 419 |
| ½ | 333 | 343 | 353 | 363 | 374 | 385 | 396 | 407 | 418 | 430 |
| 18 | 343 | 353 | 363 | 374 | 385 | 396 | 407 | 418 | 429 | 441 |
| ½ | 354 | 364 | 374 | 385 | 396 | 407 | 418 | 429 | 441 | 453 |
| 19 | 365 | 375 | 385 | 396 | 407 | 418 | 429 | 441 | 453 | 465 |
| ½ | 376 | 386 | 396 | 407 | 418 | 429 | 441 | 453 | 465 | 477 |
| 20 | 387 | 397 | 408 | 419 | 430 | 441 | 453 | 465 | 477 | 489 |
| ½ | 398 | 409 | 420 | 431 | 442 | 453 | 465 | 477 | 489 | 501 |
| 21 | 410 | 421 | 432 | 443 | 454 | 465 | 477 | 489 | 501 | 513 |
| ½ | 422 | 433 | 444 | 455 | 466 | 477 | 489 | 501 | 513 | 526 |
| 22 | 434 | 445 | 456 | 467 | 478 | 490 | 502 | 514 | 526 | 539 |
| ½ | 446 | 457 | 468 | 479 | 491 | 503 | 515 | 527 | 539 | 552 |
| 23 | 458 | 469 | 480 | 492 | 504 | 516 | 528 | 540 | 553 | 566 |
| ½ | 471 | 482 | 493 | 505 | 517 | 529 | 541 | 553 | 566 | 579 |
| 24 | 484 | 495 | 506 | 518 | 530 | 542 | 554 | 567 | 580 | 593 |
| ½ | 497 | 508 | 519 | 531 | 543 | 556 | 568 | 581 | 594 | 607 |
| 25 | 510 | 521 | 533 | 545 | 557 | 570 | 582 | 595 | 608 | 621 |
| ½ | 523 | 535 | 547 | 559 | 571 | 584 | 596 | 609 | 622 | 635 |
| 26 | 537 | 549 | 561 | 573 | 585 | 598 | 610 | 623 | 636 | 650 |
| ½ | 551 | 563 | 575 | 587 | 599 | 612 | 625 | 638 | 651 | 665 |
| 27 | 565 | 577 | 589 | 601 | 614 | 627 | 640 | 653 | 666 | 680 |
| ½ | 579 | 591 | 603 | 616 | 629 | 641 | 654 | 668 | 681 | 695 |
| 28 | 594 | 606 | 618 | 631 | 643 | 656 | 669 | 683 | 696 | 710 |
| ½ | 608 | 621 | 633 | 646 | 658 | 671 | 685 | 698 | 712 | 726 |
| 29 | 623 | 636 | 648 | 661 | 674 | 687 | 700 | 714 | 728 | 742 |
| ½ | 638 | 651 | 663 | 676 | 689 | 702 | 716 | 730 | 744 | 758 |
| 30 | 654 | 666 | 679 | 692 | 705 | 718 | 732 | 746 | 760 | 774 |
| ½ | 669 | 682 | 695 | 708 | 721 | 734 | 748 | 762 | 776 | 790 |
| 31 | 685 | 698 | 711 | 724 | 737 | 751 | 764 | 778 | 792 | 807 |
| ½ | 701 | 714 | 727 | 740 | 753 | 767 | 781 | 795 | 809 | 824 |
| 32 | 717 | 730 | 743 | 756 | 770 | 784 | 798 | 812 | 826 | 841 |
| ½ | 733 | 746 | 759 | 773 | 786 | 800 | 814 | 829 | 843 | 858 |
| 33 | 750 | 763 | 776 | 790 | 803 | 817 | 831 | 846 | 860 | 875 |
| ½ | 766 | 780 | 793 | 807 | 820 | 834 | 848 | 863 | 878 | 893 |
| 34 | 783 | 797 | 810 | 824 | 838 | 852 | 866 | 881 | 896 | 911 |
| ½ | 800 | 814 | 827 | 841 | 855 | 869 | 884 | 899 | 914 | 929 |
| 35 | 817 | 831 | 845 | 859 | 873 | 887 | 902 | 917 | 932 | 947 |
| ½ | 835 | 849 | 863 | 877 | 891 | 905 | 920 | 935 | 950 | 965 |
| 36 | 853 | 867 | 881 | 895 | 909 | 924 | 939 | 954 | 969 | 984 |
| ½ | 871 | 885 | 899 | 913 | 927 | 942 | 957 | 972 | 987 | 1003 |
| 37 | 889 | 903 | 917 | 931 | 946 | 961 | 976 | 991 | 1006 | 1022 |
| ½ | 907 | 921 | 935 | 950 | 965 | 980 | 995 | 1010 | 1025 | 1041 |
| 38 | 926 | 940 | 954 | 969 | 984 | 999 | 1014 | 1029 | 1045 | 1061 |
| ½ | 944 | 959 | 973 | 988 | 1003 | 1018 | 1033 | 1048 | 1064 | 1080 |
| 39 | 963 | 978 | 992 | 1007 | 1022 | 1037 | 1052 | 1068 | 1084 | 1100 |
| ½ | 982 | 997 | 1011 | 1026 | 1041 | 1057 | 1072 | 1088 | 1104 | 1120 |
| 40 | 1002 | 1016 | 1031 | 1046 | 1061 | 1077 | 1092 | 1108 | 1124 | 1140 |
| ½ | 1021 | 1036 | 1051 | 1066 | 1081 | 1097 | 1112 | 1128 | 1144 | 1161 |
| 41 | 1041 | 1056 | 1071 | 1086 | 1101 | 1117 | 1133 | 1149 | 1165 | 1182 |
| ½ | 1061 | 1076 | 1091 | 1106 | 1121 | 1137 | 1153 | 1170 | 1186 | 1203 |
| 42 | 1081 | 1096 | 1111 | 1127 | 1142 | 1158 | 1174 | 1191 | 1207 | 1224 |
| ½ | 1102 | 1117 | 1132 | 1148 | 1163 | 1179 | 1195 | 1212 | 1228 | 1245 |
| 43 | 1122 | 1138 | 1153 | 1169 | 1184 | 1200 | 1216 | 1233 | 1249 | 1266 |
| ½ | 1143 | 1159 | 1174 | 1190 | 1205 | 1221 | 1237 | 1254 | 1271 | 1288 |
| 44 | 1164 | 1180 | 1195 | 1211 | 1227 | 1243 | 1259 | 1276 | 1293 | 1310 |
| ½ | 1185 | 1201 | 1216 | 1232 | 1248 | 1265 | 1281 | 1298 | 1315 | 1332 |
| 45 | 1206 | 1222 | 1238 | 1254 | 1270 | 1287 | 1303 | 1320 | 1337 | 1354 |
| ½ | 1228 | 1244 | 1260 | 1276 | 1292 | 1309 | 1325 | 1342 | 1359 | 1377 |
| 46 | 1250 | 1266 | 1282 | 1298 | 1314 | 1331 | 1348 | 1365 | 1382 | 1400 |
| ½ | 1272 | 1288 | 1304 | 1320 | 1336 | 1353 | 1370 | 1388 | 1405 | 1423 |
| 47 | 1294 | 1310 | 1326 | 1342 | 1359 | 1376 | 1393 | 1411 | 1428 | 1446 |
| ½ | 1317 | 1333 | 1349 | 1365 | 1382 | 1399 | 1416 | 1434 | 1451 | 1469 |
| 48 | 1339 | 1356 | 1372 | 1388 | 1405 | 1422 | 1439 | 1457 | 1474 | 1492 |
| ½ | 1362 | 1379 | 1395 | 1411 | 1428 | 1445 | 1462 | 1480 | 1498 | 1516 |
| 49 | 1385 | 1402 | 1418 | 1435 | 1452 | 1469 | 1486 | 1504 | 1522 | 1540 |
| ½ | 1408 | 1425 | 1441 | 1458 | 1475 | 1493 | 1510 | 1528 | 1546 | 1564 |
| 50 | 1431 | 1448 | 1465 | 1482 | 1499 | 1517 | 1534 | 1552 | 1570 | 1589 |

| | ½ | 21 | ½ | 22 | ½ | 23 | ½ | 24 | ½ | 25 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 179 | 188 | 197 | 206 | 215 | 225 | 235 | 245 | 255 | 265 |
| ½ | 184 | 193 | 202 | 211 | 220 | 230 | 240 | 250 | 260 | 270 |
| 2 | 189 | 198 | 207 | 216 | 226 | 236 | 246 | 256 | 266 | 276 |
| ½ | 194 | 203 | 212 | 221 | 231 | 241 | 251 | 261 | 271 | 281 |
| 3 | 200 | 209 | 218 | 227 | 237 | 247 | 257 | 267 | 278 | 289 |
| ½ | 205 | 214 | 223 | 233 | 243 | 253 | 263 | 273 | 284 | 296 |
| 4 | 211 | 220 | 229 | 239 | 249 | 259 | 269 | 280 | 291 | 302 |
| ½ | 217 | 226 | 235 | 245 | 255 | 265 | 275 | 286 | 297 | 308 |
| 5 | 223 | 232 | 242 | 252 | 262 | 272 | 282 | 293 | 304 | 315 |
| ½ | 229 | 238 | 248 | 258 | 268 | 279 | 289 | 300 | 311 | 322 |
| 6 | 235 | 245 | 255 | 265 | 275 | 286 | 297 | 308 | 319 | 330 |
| ½ | 242 | 252 | 262 | 272 | 282 | 293 | 304 | 315 | 326 | 338 |
| 7 | 249 | 259 | 269 | 279 | 290 | 301 | 312 | 323 | 334 | 346 |
| ½ | 256 | 266 | 276 | 287 | 297 | 308 | 319 | 331 | 342 | 354 |
| 8 | 264 | 274 | 284 | 295 | 305 | 316 | 327 | 339 | 350 | 362 |
| ½ | 271 | 281 | 292 | 303 | 313 | 324 | 336 | 347 | 358 | 370 |
| 9 | 279 | 289 | 300 | 311 | 322 | 333 | 344 | 355 | 367 | 379 |
| ½ | 287 | 297 | 308 | 319 | 330 | 341 | 353 | 364 | 376 | 388 |
| 10 | 295 | 306 | 316 | 327 | 338 | 350 | 361 | 373 | 385 | 397 |
| ½ | 303 | 314 | 325 | 336 | 347 | 359 | 370 | 382 | 394 | 406 |
| 11 | 312 | 323 | 334 | 345 | 356 | 368 | 379 | 391 | 403 | 416 |
| ½ | 321 | 332 | 343 | 354 | 365 | 377 | 388 | 400 | 412 | 425 |
| 12 | 330 | 341 | 352 | 363 | 374 | 386 | 398 | 410 | 422 | 435 |
| ½ | 339 | 350 | 361 | 372 | 384 | 396 | 408 | 420 | 432 | 445 |
| 13 | 348 | 359 | 371 | 382 | 394 | 406 | 418 | 430 | 443 | 456 |
| ½ | 358 | 369 | 381 | 392 | 404 | 416 | 428 | 440 | 453 | 466 |
| 14 | 368 | 379 | 391 | 402 | 414 | 426 | 438 | 451 | 464 | 477 |
| ½ | 378 | 389 | 401 | 412 | 424 | 436 | 449 | 462 | 475 | 488 |
| 15 | 388 | 400 | 411 | 423 | 435 | 447 | 460 | 473 | 486 | 499 |
| ½ | 398 | 410 | 422 | 434 | 446 | 458 | 471 | 484 | 497 | 510 |
| 16 | 409 | 421 | 433 | 445 | 457 | 469 | 482 | 495 | 508 | 521 |
| ½ | 420 | 432 | 444 | 456 | 468 | 480 | 493 | 506 | 519 | 533 |
| 17 | 431 | 443 | 455 | 467 | 479 | 492 | 505 | 518 | 531 | 545 |
| ½ | 442 | 454 | 466 | 478 | 491 | 504 | 517 | 530 | 543 | 557 |
| 18 | 453 | 465 | 477 | 490 | 503 | 516 | 529 | 542 | 556 | 570 |
| ½ | 465 | 477 | 489 | 502 | 515 | 528 | 541 | 554 | 568 | 582 |
| 19 | 477 | 489 | 501 | 514 | 527 | 540 | 553 | 567 | 581 | 595 |
| ½ | 489 | 501 | 513 | 526 | 539 | 553 | 566 | 580 | 594 | 608 |
| 20 | 501 | 513 | 526 | 539 | 552 | 566 | 579 | 593 | 607 | 621 |
| ½ | 513 | 526 | 539 | 552 | 565 | 579 | 592 | 606 | 620 | 635 |
| 21 | 526 | 539 | 552 | 565 | 578 | 592 | 605 | 619 | 634 | 649 |
| ½ | 539 | 552 | 565 | 578 | 591 | 605 | 619 | 633 | 648 | 662 |
| 22 | 552 | 565 | 578 | 591 | 605 | 619 | 633 | 647 | 661 | 676 |
| ½ | 565 | 578 | 591 | 605 | 618 | 632 | 647 | 661 | 675 | 690 |
| 23 | 579 | 592 | 605 | 619 | 632 | 646 | 661 | 675 | 689 | 704 |
| ½ | 592 | 605 | 619 | 633 | 646 | 661 | 675 | 689 | 704 | 719 |
| 24 | 606 | 619 | 633 | 647 | 661 | 675 | 689 | 704 | 718 | 733 |
| ½ | 620 | 634 | 648 | 661 | 675 | 689 | 704 | 718 | 733 | 748 |
| 25 | 634 | 648 | 662 | 676 | 690 | 704 | 719 | 733 | 748 | 764 |
| ½ | 648 | 662 | 676 | 690 | 704 | 719 | 734 | 749 | 764 | 779 |
| 26 | 663 | 677 | 691 | 705 | 719 | 734 | 749 | 764 | 779 | 795 |
| ½ | 678 | 692 | 706 | 720 | 734 | 749 | 764 | 779 | 795 | 810 |
| 27 | 693 | 707 | 721 | 736 | 750 | 765 | 780 | 795 | 810 | 826 |
| ½ | 708 | 722 | 736 | 751 | 766 | 781 | 796 | 811 | 826 | 842 |
| 28 | 724 | 738 | 752 | 767 | 782 | 797 | 812 | 828 | 843 | 859 |
| ½ | 740 | 754 | 768 | 783 | 798 | 813 | 828 | 844 | 859 | 875 |
| 29 | 756 | 770 | 784 | 799 | 814 | 830 | 845 | 861 | 876 | 892 |
| ½ | 772 | 786 | 800 | 815 | 830 | 846 | 861 | 877 | 893 | 909 |
| 30 | 788 | 802 | 817 | 832 | 847 | 863 | 878 | 894 | 910 | 927 |
| ½ | 804 | 819 | 834 | 849 | 864 | 880 | 895 | 911 | 927 | 944 |
| 31 | 821 | 836 | 851 | 866 | 881 | 897 | 913 | 929 | 945 | 962 |
| ½ | 838 | 853 | 868 | 883 | 898 | 914 | 930 | 946 | 963 | 980 |
| 32 | 855 | 870 | 885 | 901 | 916 | 932 | 948 | 964 | 981 | 998 |
| ½ | 872 | 887 | 902 | 918 | 934 | 950 | 966 | 982 | 999 | 1016 |
| 33 | 890 | 905 | 920 | 936 | 952 | 968 | 984 | 1001 | 1017 | 1034 |
| ½ | 908 | 923 | 938 | 954 | 970 | 986 | 1002 | 1019 | 1036 | 1053 |
| 34 | 926 | 941 | 957 | 973 | 989 | 1005 | 1021 | 1038 | 1055 | 1072 |
| ½ | 944 | 959 | 975 | 991 | 1007 | 1023 | 1040 | 1057 | 1074 | 1091 |
| 35 | 962 | 978 | 994 | 1010 | 1026 | 1042 | 1059 | 1076 | 1093 | 1110 |
| ½ | 980 | 996 | 1012 | 1029 | 1045 | 1061 | 1078 | 1095 | 1112 | 1129 |
| 36 | 999 | 1015 | 1031 | 1048 | 1064 | 1081 | 1097 | 1114 | 1131 | 1149 |
| ½ | 1018 | 1034 | 1050 | 1067 | 1083 | 1100 | 1117 | 1134 | 1151 | 1169 |
| 37 | 1038 | 1054 | 1070 | 1086 | 1103 | 1120 | 1137 | 1154 | 1171 | 1189 |
| ½ | 1057 | 1073 | 1089 | 1106 | 1123 | 1140 | 1157 | 1174 | 1191 | 1209 |
| 38 | 1077 | 1093 | 1109 | 1126 | 1143 | 1160 | 1177 | 1194 | 1212 | 1230 |
| ½ | 1096 | 1113 | 1129 | 1146 | 1163 | 1180 | 1197 | 1214 | 1232 | 1250 |
| 39 | 1116 | 1133 | 1149 | 1166 | 1183 | 1200 | 1217 | 1235 | 1253 | 1271 |
| ½ | 1136 | 1153 | 1169 | 1186 | 1203 | 1221 | 1238 | 1256 | 1274 | 1292 |
| 40 | 1156 | 1173 | 1190 | 1207 | 1224 | 1242 | 1259 | 1277 | 1295 | 1314 |
| ½ | 1177 | 1194 | 1211 | 1228 | 1245 | 1263 | 1280 | 1298 | 1316 | 1335 |
| 41 | 1198 | 1215 | 1232 | 1249 | 1266 | 1284 | 1302 | 1320 | 1338 | 1357 |
| ½ | 1219 | 1236 | 1253 | 1270 | 1287 | 1305 | 1323 | 1342 | 1360 | 1379 |
| 42 | 1240 | 1257 | 1274 | 1292 | 1309 | 1327 | 1345 | 1364 | 1382 | 1401 |
| ½ | 1262 | 1279 | 1296 | 1314 | 1331 | 1349 | 1367 | 1386 | 1404 | 1423 |
| 43 | 1283 | 1301 | 1318 | 1336 | 1353 | 1371 | 1389 | 1408 | 1427 | 1446 |
| ½ | 1305 | 1323 | 1340 | 1358 | 1375 | 1393 | 1411 | 1430 | 1449 | 1468 |
| 44 | 1327 | 1345 | 1362 | 1380 | 1398 | 1416 | 1434 | 1453 | 1472 | 1491 |
| ½ | 1349 | 1367 | 1384 | 1402 | 1420 | 1439 | 1457 | 1476 | 1495 | 1514 |
| 45 | 1371 | 1389 | 1407 | 1425 | 1443 | 1462 | 1480 | 1499 | 1518 | 1538 |
| ½ | 1394 | 1412 | 1430 | 1448 | 1466 | 1485 | 1503 | 1522 | 1541 | 1561 |
| 46 | 1417 | 1435 | 1453 | 1471 | 1489 | 1508 | 1527 | 1546 | 1565 | 1585 |
| ½ | 1440 | 1458 | 1476 | 1494 | 1513 | 1532 | 1551 | 1570 | 1589 | 1609 |
| 47 | 1463 | 1481 | 1499 | 1518 | 1537 | 1556 | 1575 | 1594 | 1613 | 1633 |
| ½ | 1487 | 1505 | 1523 | 1542 | 1561 | 1580 | 1599 | 1618 | 1637 | 1657 |
| 48 | 1510 | 1529 | 1547 | 1566 | 1585 | 1604 | 1623 | 1642 | 1662 | 1682 |
| ½ | 1534 | 1553 | 1571 | 1590 | 1609 | 1628 | 1647 | 1667 | 1687 | 1707 |
| 49 | 1558 | 1577 | 1595 | 1614 | 1633 | 1653 | 1672 | 1692 | 1712 | 1732 |
| ½ | 1582 | 1601 | 1620 | 1639 | 1658 | 1677 | 1697 | 1717 | 1737 | 1757 |
| 50 | 1607 | 1626 | 1645 | 1664 | 1683 | 1702 | 1722 | 1742 | 1762 | 1782 |

| | ½ | 26 | ½ | 27 | ½ | 28 | ½ | 29 | ½ | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 275 | 286 | 287 | 308 | 319 | 331 | 343 | 355 | 367 | 379 |
| ½ | 281 | 292 | 303 | 314 | 325 | 337 | 349 | 361 | 373 | 385 |
| 2 | 287 | 298 | 309 | 320 | 332 | 344 | 356 | 368 | 380 | 392 |
| ½ | 293 | 304 | 315 | 326 | 338 | 350 | 362 | 374 | 387 | 399 |
| 3 | 300 | 311 | 322 | 333 | 345 | 357 | 369 | 381 | 394 | 407 |
| ½ | 306 | 317 | 328 | 340 | 352 | 364 | 376 | 388 | 401 | 414 |
| 4 | 313 | 324 | 335 | 347 | 359 | 371 | 383 | 396 | 409 | 422 |
| ½ | 320 | 331 | 342 | 354 | 366 | 378 | 391 | 404 | 417 | 430 |
| 5 | 326 | 338 | 350 | 362 | 374 | 386 | 399 | 412 | 425 | 438 |
| ½ | 333 | 345 | 357 | 369 | 381 | 394 | 407 | 420 | 433 | 446 |
| 6 | 341 | 353 | 365 | 377 | 389 | 402 | 415 | 428 | 441 | 454 |
| ½ | 349 | 361 | 373 | 385 | 397 | 410 | 423 | 436 | 449 | 463 |
| 7 | 357 | 369 | 381 | 394 | 406 | 419 | 432 | 444 | 458 | 472 |
| ½ | 365 | 377 | 389 | 402 | 414 | 427 | 440 | 454 | 467 | 481 |
| 8 | 373 | 385 | 398 | 411 | 423 | 436 | 449 | 463 | 476 | 490 |
| ½ | 381 | 394 | 407 | 420 | 432 | 445 | 458 | 472 | 485 | 499 |
| 9 | 390 | 403 | 416 | 429 | 442 | 454 | 468 | 482 | 495 | 509 |
| ½ | 399 | 412 | 425 | 438 | 451 | 464 | 477 | 491 | 505 | 519 |
| 10 | 409 | 422 | 434 | 447 | 460 | 474 | 487 | 501 | 515 | 529 |
| ½ | 418 | 431 | 444 | 457 | 470 | 484 | 497 | 511 | 525 | 539 |
| 11 | 428 | 441 | 454 | 467 | 480 | 494 | 508 | 522 | 536 | 550 |
| ½ | 438 | 451 | 464 | 477 | 490 | 504 | 518 | 532 | 546 | 561 |
| 12 | 448 | 461 | 474 | 487 | 501 | 515 | 529 | 543 | 557 | 572 |
| ½ | 458 | 471 | 484 | 498 | 511 | 525 | 539 | 554 | 568 | 583 |
| 13 | 469 | 482 | 495 | 509 | 522 | 536 | 550 | 565 | 579 | 594 |
| ½ | 479 | 492 | 506 | 520 | 533 | 547 | 561 | 576 | 590 | 605 |
| 14 | 490 | 503 | 517 | 531 | 545 | 559 | 573 | 588 | 602 | 617 |
| ½ | 501 | 514 | 528 | 542 | 556 | 570 | 584 | 599 | 614 | 629 |
| 15 | 512 | 526 | 539 | 553 | 567 | 582 | 596 | 611 | 626 | 641 |
| ½ | 523 | 537 | 551 | 565 | 579 | 594 | 608 | 623 | 638 | 654 |
| 16 | 535 | 549 | 563 | 577 | 591 | 606 | 621 | 636 | 651 | 666 |
| ½ | 547 | 561 | 575 | 589 | 603 | 618 | 633 | 648 | 663 | 679 |
| 17 | 559 | 573 | 587 | 601 | 616 | 631 | 646 | 661 | 676 | 692 |
| ½ | 571 | 585 | 599 | 614 | 629 | 643 | 658 | 674 | 689 | 705 |
| 18 | 583 | 598 | 612 | 627 | 641 | 656 | 671 | 687 | 702 | 718 |
| ½ | 596 | 610 | 625 | 640 | 654 | 669 | 685 | 700 | 716 | 732 |
| 19 | 609 | 623 | 638 | 653 | 668 | 683 | 698 | 714 | 730 | 746 |
| ½ | 621 | 636 | 651 | 666 | 681 | 696 | 712 | 728 | 744 | 760 |
| 20 | 635 | 650 | 665 | 680 | 695 | 710 | 726 | 742 | 758 | 774 |
| ½ | 648 | 663 | 678 | 693 | 708 | 724 | 740 | 756 | 772 | 788 |
| 21 | 662 | 677 | 692 | 707 | 722 | 738 | 754 | 770 | 786 | 802 |
| ½ | 676 | 691 | 706 | 721 | 736 | 752 | 768 | 784 | 800 | 817 |
| 22 | 690 | 705 | 720 | 736 | 751 | 767 | 783 | 799 | 815 | 832 |
| ½ | 704 | 719 | 734 | 750 | 766 | 782 | 798 | 814 | 830 | 847 |
| 23 | 719 | 734 | 749 | 765 | 781 | 797 | 813 | 830 | 846 | 863 |
| ½ | 734 | 749 | 764 | 780 | 796 | 812 | 828 | 845 | 861 | 878 |
| 24 | 749 | 764 | 779 | 795 | 811 | 828 | 844 | 861 | 877 | 894 |
| ½ | 764 | 779 | 794 | 810 | 826 | 843 | 859 | 876 | 893 | 910 |
| 25 | 779 | 795 | 810 | 826 | 842 | 859 | 875 | 892 | 909 | 927 |
| ½ | 795 | 810 | 826 | 842 | 858 | 875 | 891 | 908 | 925 | 943 |
| 26 | 810 | 826 | 842 | 858 | 874 | 891 | 908 | 925 | 942 | 960 |
| ½ | 826 | 842 | 858 | 874 | 890 | 907 | 924 | 941 | 959 | 976 |
| 27 | 842 | 858 | 874 | 891 | 907 | 924 | 941 | 958 | 976 | 993 |
| ½ | 858 | 874 | 890 | 907 | 924 | 941 | 958 | 975 | 993 | 1010 |
| 28 | 875 | 891 | 907 | 924 | 941 | 958 | 975 | 993 | 1010 | 1028 |
| ½ | 891 | 908 | 924 | 941 | 958 | 975 | 992 | 1010 | 1028 | 1045 |
| 29 | 908 | 925 | 941 | 958 | 975 | 993 | 1010 | 1028 | 1045 | 1063 |
| ½ | 926 | 942 | 959 | 976 | 993 | 1010 | 1028 | 1045 | 1063 | 1081 |
| 30 | 943 | 960 | 976 | 993 | 1010 | 1028 | 1045 | 1063 | 1081 | 1100 |
| ½ | 961 | 977 | 994 | 1011 | 1028 | 1046 | 1063 | 1081 | 1100 | 1118 |
| 31 | 978 | 995 | 1012 | 1029 | 1046 | 1064 | 1082 | 1100 | 1118 | 1137 |
| ½ | 1000 | 1013 | 1030 | 1047 | 1064 | 1082 | 1100 | 1119 | 1137 | 1156 |
| 32 | 1014 | 1031 | 1048 | 1066 | 1083 | 1101 | 1119 | 1138 | 1156 | 1175 |
| ½ | 1032 | 1049 | 1066 | 1084 | 1102 | 1120 | 1138 | 1157 | 1175 | 1194 |
| 33 | 1051 | 1068 | 1085 | 1103 | 1121 | 1139 | 1157 | 1176 | 1194 | 1213 |
| ½ | 1070 | 1087 | 1104 | 1122 | 1140 | 1158 | 1176 | 1195 | 1214 | 1234 |
| 34 | 1089 | 1106 | 1124 | 1142 | 1160 | 1178 | 1196 | 1215 | 1234 | 1253 |
| ½ | 1108 | 1125 | 1143 | 1161 | 1179 | 1197 | 1216 | 1235 | 1254 | 1273 |
| 35 | 1127 | 1145 | 1163 | 1181 | 1199 | 1217 | 1236 | 1255 | 1274 | 1293 |
| ½ | 1147 | 1164 | 1182 | 1201 | 1219 | 1237 | 1256 | 1275 | 1294 | 1313 |
| 36 | 1166 | 1184 | 1202 | 1221 | 1239 | 1258 | 1277 | 1296 | 1315 | 1334 |
| ½ | 1186 | 1204 | 1222 | 1241 | 1260 | 1278 | 1297 | 1316 | 1335 | 1355 |
| 37 | 1206 | 1225 | 1243 | 1261 | 1280 | 1299 | 1318 | 1337 | 1356 | 1376 |
| ½ | 1227 | 1245 | 1263 | 1282 | 1301 | 1320 | 1339 | 1358 | 1377 | 1397 |
| 38 | 1247 | 1266 | 1284 | 1303 | 1322 | 1341 | 1360 | 1380 | 1399 | 1419 |
| ½ | 1268 | 1287 | 1305 | 1324 | 1343 | 1362 | 1381 | 1401 | 1421 | 1441 |
| 39 | 1289 | 1308 | 1326 | 1345 | 1364 | 1384 | 1403 | 1423 | 1443 | 1463 |
| ½ | 1311 | 1329 | 1347 | 1366 | 1385 | 1405 | 1425 | 1445 | 1465 | 1485 |
| 40 | 1332 | 1351 | 1369 | 1388 | 1407 | 1427 | 1447 | 1467 | 1487 | 1507 |
| ½ | 1354 | 1372 | 1391 | 1410 | 1429 | 1449 | 1469 | 1489 | 1509 | 1529 |
| 41 | 1375 | 1394 | 1413 | 1432 | 1452 | 1472 | 1492 | 1512 | 1532 | 1552 |
| ½ | 1397 | 1416 | 1435 | 1455 | 1474 | 1494 | 1514 | 1534 | 1554 | 1575 |
| 42 | 1419 | 1439 | 1458 | 1477 | 1497 | 1517 | 1537 | 1557 | 1577 | 1598 |
| ½ | 1442 | 1461 | 1480 | 1500 | 1520 | 1540 | 1560 | 1580 | 1600 | 1621 |
| 43 | 1464 | 1484 | 1503 | 1523 | 1543 | 1563 | 1583 | 1603 | 1624 | 1645 |
| ½ | 1487 | 1507 | 1526 | 1546 | 1566 | 1586 | 1606 | 1627 | 1648 | 1669 |
| 44 | 1510 | 1530 | 1549 | 1569 | 1589 | 1610 | 1630 | 1651 | 1672 | 1693 |
| ½ | 1534 | 1553 | 1573 | 1593 | 1613 | 1633 | 1654 | 1675 | 1696 | 1717 |
| 45 | 1557 | 1577 | 1597 | 1617 | 1637 | 1657 | 1678 | 1699 | 1710 | 1741 |
| ½ | 1581 | 1600 | 1620 | 1641 | 1661 | 1681 | 1702 | 1723 | 1744 | 1766 |
| 46 | 1604 | 1624 | 1644 | 1665 | 1685 | 1706 | 1727 | 1748 | 1769 | 1791 |
| ½ | 1628 | 1648 | 1668 | 1689 | 1709 | 1730 | 1751 | 1773 | 1794 | 1816 |
| 47 | 1652 | 1673 | 1693 | 1714 | 1734 | 1755 | 1776 | 1798 | 1819 | 1841 |
| ½ | 1677 | 1697 | 1717 | 1738 | 1759 | 1780 | 1801 | 1823 | 1844 | 1866 |
| 48 | 1702 | 1722 | 1742 | 1763 | 1784 | 1805 | 1826 | 1848 | 1870 | 1892 |
| ½ | 1727 | 1747 | 1767 | 1788 | 1809 | 1830 | 1851 | 1873 | 1895 | 1917 |
| 49 | 1752 | 1772 | 1793 | 1814 | 1835 | 1856 | 1877 | 1899 | 1921 | 1943 |
| ½ | 1777 | 1797 | 1818 | 1839 | 1860 | 1882 | 1903 | 1925 | 1947 | 1969 |
| 50 | 1802 | 1823 | 1844 | 1865 | 1886 | 1908 | 1930 | 1952 | 1974 | 1996 |

| | ½ | 31 | ½ | 32 | ½ | 33 | ½ | 34 | ½ | 35 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 391 | 404 | 417 | 430 | 443 | 457 | 471 | 485 | 499 | 513 |
| ½ | 398 | 411 | 424 | 437 | 450 | 464 | 478 | 492 | 506 | 521 |
| 2 | 405 | 418 | 431 | 445 | 458 | 472 | 486 | 500 | 514 | 529 |
| ½ | 412 | 425 | 438 | 452 | 465 | 479 | 493 | 508 | 522 | 537 |
| 3 | 420 | 433 | 446 | 460 | 473 | 487 | 501 | 516 | 530 | 545 |
| ½ | 427 | 440 | 454 | 468 | 481 | 495 | 509 | 524 | 538 | 553 |
| 4 | 435 | 448 | 462 | 476 | 490 | 504 | 518 | 533 | 547 | 562 |
| ½ | 443 | 456 | 470 | 484 | 498 | 512 | 526 | 541 | 556 | 571 |
| 5 | 451 | 465 | 478 | 492 | 506 | 521 | 535 | 550 | 565 | 580 |
| ½ | 459 | 473 | 487 | 501 | 515 | 530 | 544 | 559 | 574 | 589 |
| 6 | 468 | 482 | 496 | 510 | 524 | 539 | 553 | 568 | 583 | 599 |
| ½ | 477 | 491 | 505 | 519 | 533 | 548 | 563 | 578 | 593 | 609 |
| 7 | 486 | 500 | 514 | 528 | 542 | 557 | 572 | 588 | 603 | 619 |
| ½ | 495 | 509 | 523 | 537 | 552 | 567 | 582 | 598 | 613 | 629 |
| 8 | 504 | 518 | 532 | 547 | 562 | 577 | 592 | 608 | 623 | 639 |
| ½ | 513 | 527 | 542 | 557 | 572 | 587 | 602 | 618 | 633 | 649 |
| 9 | 523 | 538 | 552 | 567 | 582 | 597 | 612 | 628 | 644 | 660 |
| ½ | 533 | 548 | 563 | 577 | 592 | 608 | 623 | 639 | 655 | 671 |
| 10 | 543 | 558 | 573 | 588 | 603 | 619 | 634 | 650 | 666 | 682 |
| ½ | 553 | 568 | 583 | 598 | 614 | 630 | 645 | 661 | 677 | 693 |
| 11 | 564 | 579 | 594 | 610 | 625 | 641 | 656 | 672 | 688 | 705 |
| ½ | 575 | 590 | 605 | 621 | 636 | 652 | 668 | 684 | 700 | 717 |
| 12 | 586 | 601 | 616 | 632 | 647 | 663 | 679 | 696 | 712 | 729 |
| ½ | 597 | 612 | 627 | 643 | 659 | 675 | 691 | 708 | 724 | 741 |
| 13 | 609 | 624 | 639 | 655 | 671 | 687 | 703 | 720 | 736 | 753 |
| ½ | 620 | 636 | 651 | 667 | 683 | 699 | 715 | 732 | 748 | 765 |
| 14 | 632 | 648 | 663 | 679 | 695 | 711 | 727 | 744 | 761 | 778 |
| ½ | 644 | 660 | 675 | 691 | 707 | 724 | 740 | 757 | 774 | 791 |
| 15 | 656 | 672 | 688 | 704 | 720 | 737 | 753 | 770 | 787 | 804 |
| ½ | 669 | 685 | 701 | 717 | 733 | 750 | 766 | 783 | 800 | 817 |
| 16 | 682 | 698 | 714 | 730 | 746 | 763 | 780 | 797 | 814 | 831 |
| ½ | 695 | 711 | 727 | 743 | 759 | 776 | 793 | 810 | 827 | 845 |
| 17 | 708 | 724 | 740 | 756 | 773 | 790 | 807 | 824 | 841 | 859 |
| ½ | 721 | 737 | 753 | 770 | 786 | 803 | 820 | 838 | 855 | 873 |
| 18 | 734 | 751 | 767 | 784 | 800 | 817 | 834 | 852 | 869 | 887 |
| ½ | 748 | 764 | 781 | 798 | 814 | 831 | 848 | 866 | 884 | 902 |
| 19 | 762 | 778 | 795 | 812 | 829 | 846 | 863 | 881 | 899 | 917 |
| ½ | 776 | 792 | 809 | 826 | 843 | 860 | 878 | 896 | 914 | 932 |
| 20 | 790 | 807 | 824 | 841 | 858 | 875 | 893 | 911 | 929 | 947 |
| ½ | 804 | 821 | 838 | 855 | 872 | 890 | 908 | 926 | 944 | 962 |
| 21 | 819 | 836 | 853 | 870 | 887 | 905 | 923 | 941 | 959 | 978 |
| ½ | 834 | 851 | 868 | 885 | 902 | 920 | 938 | 957 | 975 | 994 |
| 22 | 849 | 866 | 883 | 901 | 918 | 936 | 954 | 973 | 991 | 1010 |
| ½ | 864 | 881 | 898 | 916 | 934 | 952 | 970 | 989 | 1007 | 1026 |
| 23 | 880 | 897 | 914 | 932 | 950 | 968 | 986 | 1005 | 1023 | 1042 |
| ½ | 895 | 913 | 930 | 948 | 966 | 984 | 1002 | 1021 | 1040 | 1059 |
| 24 | 911 | 929 | 946 | 964 | 982 | 1001 | 1019 | 1038 | 1057 | 1076 |
| ½ | 927 | 945 | 963 | 981 | 999 | 1017 | 1036 | 1055 | 1074 | 1093 |
| 25 | 944 | 962 | 980 | 998 | 1016 | 1034 | 1053 | 1072 | 1091 | 1110 |
| ½ | 961 | 978 | 997 | 1014 | 1032 | 1051 | 1070 | 1089 | 1108 | 1127 |
| 26 | 977 | 995 | 1013 | 1031 | 1049 | 1068 | 1087 | 1106 | 1125 | 1145 |
| ½ | 994 | 1012 | 1030 | 1048 | 1066 | 1085 | 1104 | 1124 | 1143 | 1163 |
| 27 | 1011 | 1029 | 1047 | 1066 | 1084 | 1103 | 1122 | 1142 | 1161 | 1181 |
| ½ | 1028 | 1046 | 1064 | 1083 | 1102 | 1121 | 1140 | 1160 | 1179 | 1199 |
| 28 | 1046 | 1064 | 1082 | 1101 | 1120 | 1139 | 1158 | 1178 | 1197 | 1217 |
| ½ | 1063 | 1082 | 1100 | 1119 | 1138 | 1157 | 1176 | 1196 | 1216 | 1236 |
| 29 | 1081 | 1100 | 1119 | 1138 | 1157 | 1176 | 1195 | 1215 | 1235 | 1255 |
| ½ | 1100 | 1118 | 1137 | 1156 | 1175 | 1194 | 1214 | 1234 | 1254 | 1274 |
| 30 | 1118 | 1137 | 1156 | 1175 | 1194 | 1213 | 1233 | 1253 | 1273 | 1293 |
| ½ | 1136 | 1155 | 1174 | 1194 | 1213 | 1232 | 1252 | 1272 | 1292 | 1312 |
| 31 | 1155 | 1174 | 1193 | 1213 | 1232 | 1252 | 1272 | 1292 | 1312 | 1332 |
| ½ | 1174 | 1193 | 1213 | 1232 | 1251 | 1271 | 1291 | 1311 | 1331 | 1352 |
| 32 | 1194 | 1213 | 1232 | 1251 | 1271 | 1291 | 1311 | 1331 | 1351 | 1372 |
| ½ | 1213 | 1232 | 1251 | 1271 | 1291 | 1311 | 1331 | 1351 | 1371 | 1392 |
| 33 | 1232 | 1252 | 1271 | 1291 | 1311 | 1331 | 1351 | 1371 | 1392 | 1413 |
| ½ | 1252 | 1272 | 1291 | 1311 | 1331 | 1351 | 1371 | 1392 | 1413 | 1434 |
| 34 | 1272 | 1292 | 1311 | 1331 | 1351 | 1371 | 1392 | 1413 | 1434 | 1455 |
| ½ | 1292 | 1312 | 1331 | 1351 | 1371 | 1392 | 1413 | 1434 | 1455 | 1476 |
| 35 | 1312 | 1332 | 1352 | 1372 | 1392 | 1413 | 1434 | 1455 | 1476 | 1497 |
| ½ | 1333 | 1353 | 1373 | 1393 | 1413 | 1434 | 1455 | 1476 | 1497 | 1518 |
| 36 | 1354 | 1374 | 1394 | 1414 | 1434 | 1455 | 1476 | 1497 | 1518 | 1540 |
| ½ | 1375 | 1395 | 1415 | 1435 | 1456 | 1477 | 1498 | 1519 | 1540 | 1562 |
| 37 | 1396 | 1416 | 1436 | 1457 | 1478 | 1499 | 1520 | 1541 | 1562 | 1584 |
| ½ | 1417 | 1437 | 1453 | 1479 | 1500 | 1521 | 1542 | 1563 | 1584 | 1606 |
| 38 | 1439 | 1459 | 1480 | 1501 | 1522 | 1543 | 1564 | 1585 | 1607 | 1629 |
| ½ | 1461 | 1481 | 1502 | 1523 | 1544 | 1565 | 1586 | 1608 | 1630 | 1652 |
| 39 | 1483 | 1503 | 1524 | 1545 | 1566 | 1587 | 1609 | 1631 | 1653 | 1675 |
| ½ | 1505 | 1525 | 1546 | 1567 | 1588 | 1610 | 1632 | 1654 | 1676 | 1698 |
| 40 | 1527 | 1548 | 1569 | 1590 | 1611 | 1633 | 1655 | 1677 | 1699 | 1721 |
| ½ | 1550 | 1571 | 1592 | 1613 | 1634 | 1656 | 1678 | 1700 | 1722 | 1744 |
| 41 | 1573 | 1594 | 1615 | 1636 | 1657 | 1679 | 1701 | 1723 | 1745 | 1768 |
| ½ | 1596 | 1617 | 1638 | 1659 | 1681 | 1703 | 1725 | 1747 | 1769 | 1792 |
| 42 | 1619 | 1640 | 1661 | 1683 | 1705 | 1727 | 1749 | 1771 | 1793 | 1816 |
| ½ | 1642 | 1664 | 1685 | 1707 | 1729 | 1751 | 1773 | 1795 | 1818 | 1840 |
| 43 | 1666 | 1688 | 1709 | 1731 | 1753 | 1775 | 1797 | 1820 | 1842 | 1865 |
| ½ | 1690 | 1712 | 1733 | 1755 | 1777 | 1799 | 1822 | 1844 | 1867 | 1890 |
| 44 | 1714 | 1736 | 1757 | 1779 | 1801 | 1824 | 1846 | 1869 | 1892 | 1915 |
| ½ | 1738 | 1760 | 1782 | 1804 | 1826 | 1848 | 1871 | 1894 | 1917 | 1940 |
| 45 | 1763 | 1785 | 1807 | 1829 | 1851 | 1873 | 1896 | 1919 | 1942 | 1965 |
| ½ | 1787 | 1809 | 1831 | 1854 | 1876 | 1898 | 1921 | 1944 | 1967 | 1991 |
| 46 | 1812 | 1834 | 1856 | 1879 | 1901 | 1924 | 1947 | 1970 | 1993 | 2017 |
| ½ | 1838 | 1859 | 1882 | 1904 | 1927 | 1950 | 1972 | 1996 | 2019 | 2043 |
| 47 | 1863 | 1885 | 1907 | 1930 | 1953 | 1975 | 1998 | 2022 | 2045 | 2069 |
| ½ | 1888 | 1910 | 1933 | 1956 | 1978 | 2001 | 2024 | 2048 | 2071 | 2095 |
| 48 | 1914 | 1936 | 1959 | 1981 | 2004 | 2027 | 2050 | 2074 | 2098 | 2122 |
| ½ | 1929 | 1962 | 1985 | 2007 | 2030 | 2053 | 2077 | 2101 | 2125 | 2149 |
| 49 | 1965 | 1988 | 2011 | 2034 | 2057 | 2080 | 2104 | 2128 | 2152 | 2176 |
| ½ | 1991 | 2014 | 2037 | 2060 | 2083 | 2107 | 2131 | 2155 | 2179 | 2203 |
| 50 | 2018 | 2041 | 2064 | 2087 | 2110 | 2134 | 2158 | 2182 | 2206 | 2230 |

| | ½ | 36 | ½ | 37 | ½ | 38 | ½ | 39 | ½ | 40 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 528 | 543 | 558 | 573 | 588 | 604 | 620 | 636 | 652 | 668 |
| ½ | 536 | 551 | 566 | 581 | 596 | 613 | 628 | 644 | 660 | 677 |
| 2 | 544 | 559 | 574 | 589 | 605 | 621 | 637 | 653 | 669 | 686 |
| ½ | 552 | 567 | 582 | 597 | 613 | 629 | 645 | 662 | 678 | 695 |
| 3 | 560 | 575 | 590 | 606 | 622 | 638 | 654 | 671 | 687 | 704 |
| ½ | 568 | 584 | 599 | 615 | 631 | 647 | 663 | 680 | 693 | 713 |
| 4 | 577 | 593 | 608 | 624 | 640 | 656 | 672 | 689 | 706 | 723 |
| ½ | 586 | 602 | 617 | 633 | 649 | 666 | 682 | 699 | 716 | 733 |
| 5 | 595 | 611 | 627 | 643 | 659 | 676 | 692 | 709 | 726 | 743 |
| ½ | 604 | 620 | 636 | 653 | 669 | 686 | 702 | 719 | 736 | 753 |
| 6 | 614 | 630 | 646 | 663 | 679 | 696 | 712 | 729 | 746 | 764 |
| ½ | 624 | 640 | 656 | 673 | 689 | 706 | 723 | 740 | 757 | 775 |
| 7 | 634 | 650 | 666 | 683 | 699 | 716 | 733 | 751 | 768 | 786 |
| ½ | 644 | 660 | 676 | 693 | 710 | 727 | 744 | 762 | 779 | 797 |
| 8 | 655 | 671 | 687 | 704 | 721 | 738 | 755 | 773 | 790 | 808 |
| ½ | 665 | 682 | 698 | 715 | 732 | 749 | 766 | 784 | 801 | 819 |
| 9 | 676 | 693 | 709 | 726 | 743 | 760 | 777 | 795 | 813 | 831 |
| ½ | 687 | 704 | 720 | 737 | 754 | 772 | 789 | 807 | 825 | 843 |
| 10 | 698 | 715 | 732 | 749 | 766 | 784 | 801 | 819 | 837 | 855 |
| ½ | 709 | 726 | 743 | 761 | 778 | 796 | 813 | 831 | 849 | 867 |
| 11 | 721 | 738 | 755 | 773 | 790 | 808 | 825 | 843 | 861 | 880 |
| ½ | 733 | 750 | 767 | 785 | 802 | 820 | 838 | 856 | 874 | 893 |
| 12 | 745 | 762 | 779 | 797 | 814 | 832 | 850 | 869 | 887 | 906 |
| ½ | 757 | 774 | 791 | 809 | 827 | 845 | 863 | 882 | 900 | 919 |
| 13 | 770 | 787 | 804 | 822 | 840 | 858 | 876 | 895 | 913 | 932 |
| ½ | 782 | 800 | 817 | 835 | 853 | 871 | 889 | 908 | 926 | 946 |
| 14 | 795 | 813 | 830 | 848 | 866 | 885 | 903 | 922 | 941 | 960 |
| ½ | 808 | 826 | 843 | 861 | 879 | 898 | 916 | 935 | 954 | 974 |
| 15 | 821 | 839 | 857 | 875 | 893 | 912 | 930 | 949 | 968 | 988 |
| ½ | 835 | 853 | 871 | 889 | 907 | 926 | 944 | 963 | 982 | 1002 |
| 16 | 849 | 867 | 885 | 903 | 921 | 940 | 959 | 978 | 997 | 1016 |
| ½ | 863 | 881 | 899 | 917 | 935 | 954 | 973 | 992 | 1011 | 1031 |
| 17 | 877 | 895 | 913 | 931 | 950 | 969 | 988 | 1007 | 1026 | 1046 |
| ½ | 891 | 909 | 927 | 946 | 965 | 984 | 1003 | 1022 | 1041 | 1061 |
| 18 | 905 | 924 | 942 | 961 | 980 | 999 | 1018 | 1037 | 1057 | 1077 |
| ½ | 920 | 939 | 957 | 976 | 995 | 1014 | 1033 | 1052 | 1072 | 1092 |
| 19 | 935 | 954 | 972 | 991 | 1010 | 1029 | 1048 | 1068 | 1088 | 1108 |
| ½ | 950 | 969 | 987 | 1006 | 1025 | 1045 | 1064 | 1084 | 1104 | 1124 |
| 20 | 965 | 984 | 1003 | 1022 | 1041 | 1061 | 1080 | 1100 | 1120 | 1140 |
| ½ | 980 | 999 | 1018 | 1038 | 1057 | 1077 | 1096 | 1116 | 1136 | 1156 |
| 21 | 996 | 1015 | 1034 | 1054 | 1073 | 1093 | 1113 | 1153 | 1153 | 1173 |
| ½ | 1012 | 1031 | 1050 | 1070 | 1089 | 1109 | 1129 | 1149 | 1169 | 1190 |
| 22 | 1029 | 1048 | 1067 | 1086 | 1106 | 1126 | 1146 | 1166 | 1186 | 1207 |
| ½ | 1045 | 1064 | 1083 | 1103 | 1123 | 1143 | 1163 | 1183 | 1203 | 1224 |
| 23 | 1061 | 1081 | 1100 | 1120 | 1140 | 1160 | 1180 | 1200 | 1221 | 1242 |
| ½ | 1078 | 1097 | 1117 | 1137 | 1157 | 1177 | 1197 | 1217 | 1238 | 1259 |
| 24 | 1095 | 1114 | 1134 | 1154 | 1174 | 1194 | 1214 | 1235 | 1256 | 1277 |
| ½ | 1112 | 1131 | 1151 | 1171 | 1191 | 1212 | 1232 | 1253 | 1274 | 1295 |
| 25 | 1129 | 1149 | 1169 | 1189 | 1209 | 1230 | 1250 | 1271 | 1292 | 1314 |
| ½ | 1147 | 1166 | 1186 | 1206 | 1227 | 1247 | 1268 | 1289 | 1311 | 1332 |
| 26 | 1164 | 1184 | 1204 | 1225 | 1245 | 1266 | 1287 | 1308 | 1329 | 1351 |
| ½ | 1182 | 1202 | 1222 | 1243 | 1263 | 1284 | 1305 | 1326 | 1347 | 1369 |
| 27 | 1201 | 1221 | 1241 | 1261 | 1282 | 1303 | 1324 | 1345 | 1366 | 1388 |
| ½ | 1219 | 1249 | 1260 | 1280 | 1301 | 1322 | 1343 | 1364 | 1386 | 1407 |
| 28 | 1237 | 1258 | 1278 | 1299 | 1320 | 1341 | 1362 | 1384 | 1405 | 1427 |
| ½ | 1256 | 1277 | 1297 | 1318 | 1339 | 1360 | 1381 | 1403 | 1425 | 1447 |
| 29 | 1275 | 1296 | 1316 | 1337 | 1358 | 1380 | 1401 | 1423 | 1445 | 1467 |
| ½ | 1294 | 1315 | 1335 | 1356 | 1377 | 1399 | 1421 | 1443 | 1465 | 1487 |
| 30 | 1313 | 1334 | 1355 | 1376 | 1397 | 1419 | 1441 | 1463 | 1485 | 1507 |
| ½ | 1333 | 1354 | 1375 | 1396 | 1417 | 1439 | 1461 | 1483 | 1505 | 1527 |
| 31 | 1353 | 1374 | 1395 | 1416 | 1437 | 1459 | 1481 | 1503 | 1525 | 1548 |
| ½ | 1373 | 1394 | 1415 | 1436 | 1458 | 1480 | 1502 | 1524 | 1546 | 1569 |
| 32 | 1393 | 1414 | 1435 | 1457 | 1479 | 1501 | 1523 | 1545 | 1567 | 1590 |
| ½ | 1413 | 1434 | 1456 | 1478 | 1500 | 1522 | 1544 | 1566 | 1588 | 1611 |
| 33 | 1434 | 1455 | 1477 | 1499 | 1521 | 1543 | 1565 | 1587 | 1610 | 1633 |
| ½ | 1455 | 1476 | 1498 | 1520 | 1542 | 1564 | 1586 | 1609 | 1632 | 1655 |
| 34 | 1476 | 1497 | 1519 | 1541 | 1563 | 1585 | 1608 | 1631 | 1654 | 1677 |
| ½ | 1497 | 1518 | 1540 | 1562 | 1584 | 1607 | 1630 | 1653 | 1676 | 1699 |
| 35 | 1518 | 1540 | 1562 | 1584 | 1606 | 1629 | 1652 | 1675 | 1698 | 1721 |
| ½ | 1540 | 1562 | 1584 | 1606 | 1628 | 1651 | 1674 | 1697 | 1720 | 1743 |
| 36 | 1562 | 1584 | 1606 | 1628 | 1650 | 1673 | 1696 | 1719 | 1742 | 1766 |
| ½ | 1584 | 1606 | 1627 | 1650 | 1673 | 1696 | 1719 | 1742 | 1765 | 1789 |
| 37 | 1606 | 1628 | 1650 | 1673 | 1696 | 1719 | 1742 | 1765 | 1788 | 1812 |
| ½ | 1628 | 1650 | 1673 | 1696 | 1719 | 1742 | 1765 | 1788 | 1811 | 1835 |
| 38 | 1651 | 1673 | 1696 | 1719 | 1742 | 1765 | 1788 | 1811 | 1835 | 1859 |
| ½ | 1674 | 1696 | 1719 | 1742 | 1765 | 1788 | 1811 | 1835 | 1859 | 1883 |
| 39 | 1697 | 1719 | 1742 | 1765 | 1788 | 1811 | 1835 | 1859 | 1883 | 1907 |
| ½ | 1720 | 1742 | 1765 | 1788 | 1811 | 1835 | 1859 | 1883 | 1907 | 1931 |
| 40 | 1743 | 1766 | 1789 | 1812 | 1835 | 1859 | 1883 | 1907 | 1931 | 1955 |
| ½ | 1767 | 1790 | 1813 | 1836 | 1859 | 1883 | 1907 | 1931 | 1955 | 1980 |
| 41 | 1791 | 1814 | 1837 | 1860 | 1884 | 1908 | 1932 | 1956 | 1980 | 2005 |
| ½ | 1815 | 1838 | 1861 | 1884 | 1908 | 1932 | 1956 | 1980 | 2005 | 2030 |
| 42 | 1839 | 1862 | 1885 | 1909 | 1933 | 1957 | 1981 | 2005 | 2030 | 2055 |
| ½ | 1863 | 1887 | 1910 | 1934 | 1958 | 1982 | 2006 | 2030 | 2055 | 2080 |
| 43 | 1888 | 1912 | 1935 | 1959 | 1983 | 2007 | 2031 | 2056 | 2081 | 2106 |
| ½ | 1913 | 1937 | 1960 | 1984 | 2008 | 2032 | 2056 | 2081 | 2106 | 2131 |
| 44 | 1938 | 1962 | 1985 | 2009 | 2033 | 2058 | 2082 | 2107 | 2132 | 2157 |
| ½ | 1963 | 1987 | 2011 | 2035 | 2059 | 2084 | 2108 | 2133 | 2158 | 2183 |
| 45 | 1989 | 2013 | 2037 | 2061 | 2085 | 2109 | 2134 | 2159 | 2184 | 2210 |
| ½ | 2014 | 2038 | 2062 | 2087 | 2111 | 2136 | 2160 | 2185 | 2210 | 2236 |
| 46 | 2040 | 2064 | 2089 | 2113 | 2137 | 2162 | 2187 | 2212 | 2237 | 2263 |
| ½ | 2066 | 2091 | 2115 | 2139 | 2164 | 2189 | 2214 | 2239 | 2264 | 2290 |
| 47 | 2093 | 2117 | 2141 | 2166 | 2191 | 2216 | 2241 | 2266 | 2291 | 2317 |
| ½ | 2119 | 2143 | 2168 | 2193 | 2218 | 2243 | 2268 | 2293 | 2319 | 2344 |
| 48 | 2146 | 2170 | 2195 | 2220 | 2245 | 2270 | 2295 | 2321 | 2346 | 2372 |
| ½ | 2173 | 2197 | 2222 | 2247 | 2272 | 2297 | 2323 | 2348 | 2374 | 2400 |
| 49 | 2200 | 2225 | 2249 | 2274 | 2299 | 2325 | 2350 | 2376 | 2402 | 2428 |
| ½ | 2227 | 2252 | 2277 | 2302 | 2327 | 2353 | 2378 | 2404 | 2430 | 2456 |
| 50 | 2255 | 2280 | 2305 | 2330 | 2355 | 2381 | 2406 | 2432 | 2458 | 2484 |

| | ½ | 41 | ½ | 42 | ½ | 43 | ½ | 44 | ½ | 45 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 685 | 702 | 719 | 736 | 753 | 771 | 789 | 807 | 825 | 843 |
| ½ | 694 | 711 | 728 | 745 | 762 | 780 | 798 | 816 | 834 | 853 |
| 2 | 703 | 720 | 737 | 754 | 772 | 790 | 808 | 826 | 844 | 863 |
| ½ | 712 | 729 | 746 | 763 | 781 | 799 | 817 | 836 | 854 | 873 |
| 3 | 721 | 738 | 755 | 773 | 790 | 808 | 827 | 846 | 864 | 883 |
| ½ | 730 | 748 | 765 | 783 | 801 | 819 | 837 | 856 | 875 | 894 |
| 4 | 740 | 758 | 775 | 793 | 811 | 830 | 848 | 867 | 886 | 905 |
| ½ | 750 | 768 | 785 | 803 | 821 | 840 | 859 | 877 | 896 | 916 |
| 5 | 760 | 778 | 796 | 814 | 832 | 851 | 870 | 888 | 907 | 927 |
| ½ | 770 | 788 | 806 | 825 | 843 | 862 | 881 | 900 | 919 | 938 |
| 6 | 781 | 799 | 817 | 836 | 854 | 873 | 892 | 911 | 930 | 949 |
| ½ | 792 | 810 | 828 | 847 | 865 | 884 | 903 | 922 | 941 | 961 |
| 7 | 803 | 821 | 839 | 858 | 877 | 896 | 915 | 934 | 953 | 973 |
| ½ | 814 | 832 | 851 | 869 | 888 | 907 | 926 | 946 | 965 | 985 |
| 8 | 826 | 844 | 862 | 881 | 900 | 919 | 938 | 958 | 977 | 997 |
| ½ | 837 | 856 | 874 | 893 | 911 | 931 | 950 | 970 | 990 | 1010 |
| 9 | 849 | 868 | 886 | 905 | 924 | 944 | 963 | 983 | 1003 | 1023 |
| ½ | 861 | 880 | 898 | 917 | 936 | 956 | 975 | 995 | 1015 | 1036 |
| 10 | 873 | 892 | 911 | 930 | 949 | 969 | 988 | 1008 | 1028 | 1049 |
| ½ | 887 | 905 | 924 | 943 | 962 | 982 | 1001 | 1021 | 1041 | 1062 |
| 11 | 899 | 918 | 937 | 956 | 975 | 995 | 1015 | 1035 | 1055 | 1076 |
| ½ | 912 | 931 | 950 | 969 | 988 | 1008 | 1028 | 1048 | 1068 | 1089 |
| 12 | 925 | 944 | 963 | 982 | 1002 | 1022 | 1042 | 1062 | 1082 | 1103 |
| ½ | 938 | 957 | 977 | 996 | 1016 | 1036 | 1056 | 1076 | 1096 | 1117 |
| 13 | 951 | 971 | 990 | 1010 | 1030 | 1050 | 1070 | 1090 | 1111 | 1132 |
| ½ | 964 | 984 | 1004 | 1024 | 1044 | 1064 | 1084 | 1104 | 1125 | 1146 |
| 14 | 979 | 998 | 1018 | 1038 | 1058 | 1078 | 1098 | 1119 | 1140 | 1161 |
| ½ | 993 | 1012 | 1032 | 1052 | 1072 | 1092 | 1113 | 1134 | 1155 | 1176 |
| 15 | 1007 | 1027 | 1047 | 1067 | 1087 | 1107 | 1128 | 1149 | 1170 | 1191 |
| ½ | 1021 | 1041 | 1061 | 1081 | 1102 | 1122 | 1143 | 1164 | 1185 | 1206 |
| 16 | 1036 | 1056 | 1076 | 1096 | 1117 | 1138 | 1159 | 1180 | 1201 | 1222 |
| ½ | 1051 | 1071 | 1091 | 1111 | 1132 | 1153 | 1174 | 1195 | 1216 | 1238 |
| 17 | 1066 | 1086 | 1106 | 1127 | 1148 | 1169 | 1190 | 1211 | 1232 | 1254 |
| ½ | 1081 | 1101 | 1121 | 1142 | 1163 | 1184 | 1205 | 1227 | 1248 | 1270 |
| 18 | 1097 | 1117 | 1137 | 1158 | 1179 | 1200 | 1221 | 1243 | 1265 | 1287 |
| ½ | 1112 | 1133 | 1153 | 1174 | 1195 | 1216 | 1237 | 1259 | 1281 | 1303 |
| 19 | 1128 | 1149 | 1170 | 1191 | 1212 | 1233 | 1254 | 1276 | 1298 | 1320 |
| ½ | 1144 | 1165 | 1186 | 1207 | 1228 | 1249 | 1271 | 1293 | 1315 | 1337 |
| 20 | 1161 | 1182 | 1203 | 1224 | 1245 | 1266 | 1288 | 1310 | 1332 | 1354 |
| ½ | 1177 | 1198 | 1219 | 1240 | 1262 | 1283 | 1305 | 1327 | 1349 | 1371 |
| 21 | 1194 | 1215 | 1236 | 1257 | 1279 | 1301 | 1323 | 1345 | 1367 | 1389 |
| ½ | 1211 | 1232 | 1253 | 1274 | 1296 | 1318 | 1340 | 1362 | 1384 | 1407 |
| 22 | 1228 | 1249 | 1270 | 1292 | 1314 | 1336 | 1358 | 1380 | 1402 | 1425 |
| ½ | 1245 | 1266 | 1287 | 1309 | 1331 | 1353 | 1375 | 1398 | 1420 | 1443 |
| 23 | 1263 | 1284 | 1305 | 1327 | 1349 | 1371 | 1393 | 1416 | 1439 | 1462 |
| ½ | 1280 | 1302 | 1323 | 1345 | 1367 | 1389 | 1411 | 1434 | 1457 | 1480 |
| 24 | 1298 | 1320 | 1342 | 1364 | 1386 | 1408 | 1430 | 1453 | 1476 | 1499 |
| ½ | 1316 | 1338 | 1360 | 1382 | 1404 | 1427 | 1449 | 1472 | 1495 | 1518 |
| 25 | 1335 | 1357 | 1379 | 1401 | 1423 | 1446 | 1468 | 1491 | 1514 | 1538 |
| ½ | 1354 | 1375 | 1397 | 1419 | 1442 | 1464 | 1487 | 1510 | 1534 | 1557 |
| 26 | 1372 | 1394 | 1416 | 1439 | 1461 | 1484 | 1507 | 1530 | 1553 | 1577 |
| ½ | 1391 | 1413 | 1435 | 1458 | 1480 | 1503 | 1526 | 1549 | 1573 | 1597 |
| 27 | 1410 | 1433 | 1455 | 1477 | 1500 | 1523 | 1546 | 1569 | 1593 | 1617 |
| ½ | 1429 | 1452 | 1474 | 1497 | 1520 | 1543 | 1566 | 1589 | 1613 | 1637 |
| 28 | 1449 | 1472 | 1494 | 1517 | 1540 | 1563 | 1586 | 1610 | 1633 | 1657 |
| ½ | 1469 | 1492 | 1514 | 1537 | 1560 | 1583 | 1606 | 1630 | 1654 | 1678 |
| 29 | 1489 | 1512 | 1534 | 1557 | 1580 | 1603 | 1627 | 1651 | 1675 | 1699 |
| ½ | 1509 | 1532 | 1554 | 1577 | 1600 | 1624 | 1648 | 1672 | 1696 | 1720 |
| 30 | 1529 | 1552 | 1575 | 1598 | 1621 | 1645 | 1669 | 1693 | 1717 | 1741 |
| ½ | 1550 | 1573 | 1596 | 1619 | 1642 | 1666 | 1690 | 1714 | 1738 | 1763 |
| 31 | 1571 | 1594 | 1617 | 1640 | 1664 | 1688 | 1712 | 1736 | 1760 | 1785 |
| ½ | 1592 | 1615 | 1638 | 1661 | 1685 | 1709 | 1733 | 1757 | 1782 | 1807 |
| 32 | 1613 | 1636 | 1659 | 1683 | 1707 | 1731 | 1755 | 1779 | 1804 | 1829 |
| ½ | 1634 | 1657 | 1681 | 1705 | 1729 | 1753 | 1777 | 1801 | 1826 | 1851 |
| 33 | 1656 | 1679 | 1703 | 1727 | 1751 | 1775 | 1799 | 1824 | 1848 | 1873 |
| ½ | 1678 | 1701 | 1725 | 1749 | 1773 | 1797 | 1822 | 1846 | 1871 | 1896 |
| 34 | 1700 | 1723 | 1747 | 1771 | 1795 | 1820 | 1844 | 1869 | 1894 | 1919 |
| ½ | 1722 | 1745 | 1769 | 1793 | 1818 | 1842 | 1867 | 1892 | 1917 | 1942 |
| 35 | 1744 | 1768 | 1792 | 1816 | 1840 | 1865 | 1890 | 1915 | 1940 | 1965 |
| ½ | 1767 | 1791 | 1815 | 1839 | 1863 | 1888 | 1913 | 1938 | 1963 | 1989 |
| 36 | 1790 | 1814 | 1838 | 1862 | 1887 | 1912 | 1937 | 1962 | 1987 | 2013 |
| ½ | 1813 | 1837 | 1861 | 1885 | 1910 | 1935 | 1960 | 1985 | 2011 | 2037 |
| 37 | 1836 | 1860 | 1884 | 1909 | 1934 | 1959 | 1984 | 2009 | 2035 | 2061 |
| ½ | 1859 | 1884 | 1908 | 1933 | 1958 | 1983 | 2008 | 2033 | 2059 | 2085 |
| 38 | 1883 | 1908 | 1932 | 1957 | 1982 | 2007 | 2032 | 2058 | 2084 | 2109 |
| ½ | 1907 | 1932 | 1956 | 1981 | 2006 | 2031 | 2056 | 2082 | 2108 | 2134 |
| 39 | 1931 | 1956 | 1980 | 2005 | 2030 | 2056 | 2081 | 2107 | 2133 | 2159 |
| ½ | 1955 | 1980 | 2005 | 2030 | 2055 | 2081 | 2106 | 2132 | 2158 | 2184 |
| 40 | 1980 | 2005 | 2030 | 2055 | 2080 | 2106 | 2131 | 2157 | 2183 | 2210 |
| ½ | 2004 | 2029 | 2054 | 2079 | 2105 | 2131 | 2156 | 2182 | 2208 | 2235 |
| 41 | 2029 | 2054 | 2079 | 2105 | 2130 | 2156 | 2182 | 2208 | 2234 | 2261 |
| ½ | 2054 | 2079 | 2104 | 2130 | 2156 | 2181 | 2207 | 2233 | 2260 | 2287 |
| 42 | 2079 | 2105 | 2130 | 2156 | 2181 | 2207 | 2233 | 2260 | 2286 | 2313 |
| ½ | 2105 | 2130 | 2156 | 2181 | 2206 | 2233 | 2260 | 2286 | 2313 | 2339 |
| 43 | 2131 | 2156 | 2181 | 2207 | 2233 | 2260 | 2286 | 2313 | 2339 | 2366 |
| ½ | 2156 | 2182 | 2207 | 2233 | 2260 | 2286 | 2312 | 2339 | 2366 | 2393 |
| 44 | 2182 | 2208 | 2233 | 2260 | 2286 | 2313 | 2339 | 2366 | 2393 | 2420 |
| ½ | 2208 | 2234 | 2260 | 2286 | 2313 | 2339 | 2366 | 2393 | 2420 | 2447 |
| 45 | 2235 | 2261 | 2287 | 2313 | 2339 | 2366 | 2393 | 2420 | 2447 | 2475 |
| ½ | 2262 | 2288 | 2314 | 2340 | 2367 | 2393 | 2420 | 2447 | 2475 | 2502 |
| 46 | 2289 | 2315 | 2341 | 2368 | 2394 | 2421 | 2448 | 2475 | 2502 | 2530 |
| ½ | 2316 | 2342 | 2368 | 2395 | 2422 | 2448 | 2475 | 2503 | 2530 | 2558 |
| 47 | 2343 | 2369 | 2396 | 2423 | 2449 | 2476 | 2503 | 2531 | 2558 | 2586 |
| ½ | 2370 | 2397 | 2424 | 2450 | 2477 | 2504 | 2431 | 2559 | 2587 | 2614 |
| 48 | 2398 | 2425 | 2451 | 2478 | 2505 | 2533 | 2560 | 2588 | 2615 | 2643 |
| ½ | 2426 | 2453 | 2479 | 2506 | 2534 | 2561 | 2588 | 2616 | 2644 | 2672 |
| 49 | 2454 | 2481 | 2508 | 2535 | 2562 | 2590 | 2617 | 2645 | 2673 | 2701 |
| ½ | 2482 | 2509 | 2536 | 2563 | 2591 | 2618 | 2646 | 2674 | 2702 | 2730 |
| 50 | 2511 | 2538 | 2565 | 2592 | 2619 | 2647 | 2675 | 2703 | 2731 | 2760 |

| | ½ 46 | ½ 47 | ½ 48 | ½ 49 | ½ 50 | ½ 51 | ½ 52 | ½ 53 | ½ 54 | ½ 55 | ½ 56 | ½ 57 | ½ 58 | ½ 59 | ½ 60 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | 1039 1059 1080 1101 1122 1144 1166 1188 1210 1232 | | | | | 1254 1277 1300 1323 1346 1370 1394 1418 1442 1466 | | | | | |
| ½ | | | | | | 1049 1070 1091 1112 1133 1155 1177 1199 1221 1243 | | | | | 1266 1289 1312 1335 1358 1382 1406 1430 1454 1478 | | | | | ½ |
| 1 | 862 881 900 919 939 958 978 998 1018 1039 | | | | | 1060 1081 1102 1123 1144 1166 1188 1210 1232 1255 | | | | | 1278 1301 1324 1347 1370 1394 1418 1442 1466 1491 | | | | | |
| ½ | 872 891 910 929 949 969 988 1008 1029 1050 | | | | | 1070 1092 1113 1134 1155 1177 1199 1221 1244 1267 | | | | | 1290 1313 1336 1359 1382 1406 1430 1455 1479 1504 | | | | | ½ |
| 2 | 882 901 920 940 959 979 999 1019 1040 1061 | | | | | 1082 1103 1124 1145 1167 1189 1211 1233 1256 1279 | | | | | 1302 1325 1348 1371 1395 1419 1443 1468 1492 1517 | | | | | |
| ½ | 892 911 930 949 970 990 1010 1030 1050 1072 | | | | | 1093 1114 1135 1157 1179 1201 1223 1245 1268 1291 | | | | | 1314 1337 1360 1384 1408 1432 1456 1481 1505 1530 | | | | | ½ |
| 3 | 902 922 941 961 981 1001 1021 1041 1062 1083 | | | | | 1104 1125 1147 1169 1191 1213 1235 1257 1280 1303 | | | | | 1326 1349 1373 1397 1421 1445 1469 1494 1518 1543 | | | | | |
| ½ | 913 932 952 972 992 1012 1032 1052 1073 1094 | | | | | 1115 1137 1159 1181 1203 1225 1247 1269 1292 1315 | | | | | 1338 1362 1386 1410 1434 1458 1482 1507 1532 1557 | | | | | ½ |
| 4 | 924 943 963 983 1003 1023 1043 1064 1085 1106 | | | | | 1127 1149 1171 1193 1215 1237 1259 1282 1305 1328 | | | | | 1351 1375 1399 1423 1447 1471 1496 1521 1546 1571 | | | | | |
| ½ | 935 954 974 994 1014 1034 1055 1076 1097 1118 | | | | | 1139 1161 1183 1205 1227 1249 1272 1295 1318 1341 | | | | | 1364 1388 1412 1436 1460 1485 1510 1534 1559 1585 | | | | | ½ |
| 5 | 946 966 986 1006 1026 1046 1067 1088 1109 1130 | | | | | 1151 1173 1195 1217 1239 1262 1285 1308 1331 1354 | | | | | 1378 1402 1426 1450 1474 1499 1523 1548 1573 1599 | | | | | |
| ½ | 957 977 997 1017 1037 1058 1079 1100 1121 1142 | | | | | 1163 1186 1208 1230 1252 1275 1298 1321 1344 1367 | | | | | 1391 1415 1439 1463 1488 1513 1537 1562 1588 1613 | | | | | ½ |
| 6 | 969 989 1009 1029 1049 1070 1091 1112 1133 1155 | | | | | 1176 1199 1221 1243 1265 1288 1311 1334 1357 1381 | | | | | 1405 1429 1453 1477 1502 1527 1552 1577 1602 1628 | | | | | |
| ½ | 981 1001 1021 1041 1061 1082 1103 1125 1146 1168 | | | | | 1190 1212 1234 1256 1278 1301 1324 1348 1371 1395 | | | | | 1419 1443 1467 1491 1516 1541 1566 1591 1617 1642 | | | | | ½ |
| 7 | 993 1013 1033 1054 1074 1095 1116 1138 1159 1181 | | | | | 1203 1225 1247 1270 1292 1315 1338 1362 1385 1409 | | | | | 1433 1457 1481 1506 1531 1556 1580 1606 1631 1657 | | | | | |
| ½ | 1005 1025 1045 1066 1087 1108 1129 1151 1172 1194 | | | | | 1216 1238 1261 1283 1306 1329 1352 1376 1399 1423 | | | | | 1447 1471 1496 1520 1545 1570 1596 1621 1646 1672 | | | | | ½ |
| 8 | 1017 1038 1058 1079 1100 1121 1142 1164 1185 1207 | | | | | 1229 1252 1274 1297 1320 1343 1366 1390 1413 1437 | | | | | 1461 1486 1510 1535 1560 1585 1611 1636 1662 1688 | | | | | |
| ½ | 1030 1050 1071 1092 1113 1134 1155 1177 1199 1221 | | | | | 1243 1265 1288 1311 1334 1357 1380 1404 1428 1452 | | | | | 1476 1501 1525 1550 1575 1600 1626 1651 1677 1703 | | | | | ½ |
| 9 | 1043 1063 1084 1105 1126 1147 1169 1191 1213 1235 | | | | | 1257 1279 1302 1325 1348 1371 1395 1419 1443 1467 | | | | | 1491 1516 1540 1565 1590 1616 1641 1667 1693 1719 | | | | | |
| ½ | 1056 1076 1097 1118 1139 1161 1182 1204 1226 1249 | | | | | 1271 1293 1316 1339 1362 1386 1409 1433 1457 1482 | | | | | 1506 1531 1555 1580 1606 1631 1657 1683 1709 1735 | | | | | ½ |
| 10 | 1069 1090 1111 1132 1153 1175 1196 1218 1239 1263 | | | | | 1285 1308 1331 1354 1377 1401 1424 1448 1472 1497 | | | | | 1521 1546 1571 1596 1621 1647 1673 1699 1725 1752 | | | | | |
| ½ | 1082 1103 1124 1146 1167 1189 1210 1232 1254 1277 | | | | | 1300 1322 1345 1369 1392 1416 1439 1463 1487 1512 | | | | | 1537 1562 1587 1612 1637 1663 1689 1715 1742 1768 | | | | | ½ |
| 11 | 1096 1117 1138 1160 1181 1203 1225 1247 1269 1292 | | | | | 1314 1337 1360 1384 1407 1431 1455 1479 1503 1528 | | | | | 1553 1578 1603 1628 1653 1679 1705 1732 1758 1785 | | | | | |
| ½ | 1109 1131 1152 1174 1195 1217 1239 1261 1283 1306 | | | | | 1329 1352 1375 1399 1422 1446 1470 1494 1519 1544 | | | | | 1569 1594 1619 1644 1670 1695 1722 1748 1775 1801 | | | | | ½ |
| 12 | 1124 1145 1166 1188 1210 1232 1254 1276 1298 1321 | | | | | 1344 1367 1391 1414 1438 1462 1486 1510 1535 1560 | | | | | 1585 1610 1635 1661 1686 1712 1738 1765 1791 1818 | | | | | |
| ½ | 1138 1159 1180 1202 1224 1246 1269 1291 1313 1336 | | | | | 1359 1382 1406 1430 1454 1478 1502 1526 1551 1576 | | | | | 1601 1626 1651 1677 1703 1729 1755 1782 1808 1835 | | | | | ½ |
| 13 | 1153 1174 1195 1217 1239 1261 1283 1306 1329 1352 | | | | | 1374 1398 1422 1446 1470 1494 1518 1543 1567 1592 | | | | | 1617 1643 1668 1694 1720 1746 1772 1799 1826 1853 | | | | | |
| ½ | 1168 1189 1210 1232 1254 1276 1298 1321 1344 1367 | | | | | 1390 1414 1438 1462 1486 1510 1534 1559 1584 1609 | | | | | 1634 1660 1685 1711 1737 1763 1789 1816 1843 1870 | | | | | ½ |
| 14 | 1182 1204 1226 1248 1270 1292 1314 1337 1360 1383 | | | | | 1406 1430 1454 1478 1502 1526 1551 1576 1601 1626 | | | | | 1651 1677 1702 1728 1754 1781 1807 1834 1861 1888 | | | | | |
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| 15 | 1213 1235 1257 1279 1301 1323 1346 1369 1392 1415 | | | | | 1438 1463 1487 1511 1535 1560 1584 1609 1634 1660 | | | | | 1685 1711 1737 1763 1789 1816 1843 1870 1897 1925 | | | | | |
| ½ | 1228 1250 1272 1294 1317 1339 1362 1385 1408 1431 | | | | | 1454 1479 1503 1528 1552 1577 1601 1626 1651 1677 | | | | | 1703 1729 1755 1781 1807 1834 1861 1888 1916 1943 | | | | | ½ |
| 16 | 1244 1266 1288 1310 1333 1356 1379 1402 1425 1448 | | | | | 1472 1496 1520 1545 1569 1594 1619 1644 1669 1695 | | | | | 1721 1747 1773 1799 1826 1853 1880 1907 1934 1962 | | | | | |
| ½ | 1260 1282 1304 1326 1349 1372 1395 1418 1441 1465 | | | | | 1489 1513 1537 1562 1586 1611 1636 1661 1687 1713 | | | | | 1739 1765 1791 1817 1844 1871 1898 1925 1953 1981 | | | | | ½ |
| 17 | 1276 1298 1320 1342 1365 1388 1411 1435 1458 1482 | | | | | 1506 1530 1554 1579 1604 1629 1654 1679 1705 1731 | | | | | 1757 1783 1809 1836 1863 1890 1917 1944 1972 2000 | | | | | |
| ½ | 1292 1314 1336 1359 1382 1405 1428 1452 1475 1499 | | | | | 1523 1547 1572 1597 1622 1647 1672 1697 1723 1749 | | | | | 1775 1801 1828 1854 1881 1909 1936 1963 1991 2019 | | | | | ½ |
| 18 | 1309 1331 1353 1376 1399 1422 1445 1469 1493 1517 | | | | | 1540 1565 1590 1615 1640 1665 1690 1716 1741 1767 | | | | | 1793 1820 1846 1873 1901 1928 1955 1983 2010 2038 | | | | | |
| ½ | 1325 1348 1370 1393 1416 1439 1462 1486 1510 1534 | | | | | 1558 1583 1608 1633 1658 1683 1708 1734 1760 1786 | | | | | 1812 1839 1865 1893 1920 1947 1974 2002 2030 2058 | | | | | ½ |
| 19 | 1342 1365 1388 1411 1434 1457 1480 1504 1528 1552 | | | | | 1576 1601 1626 1651 1676 1701 1727 1753 1779 1805 | | | | | 1831 1858 1885 1912 1939 1966 1994 2022 2050 2078 | | | | | |
| ½ | 1359 1382 1405 1428 1451 1474 1498 1522 1546 1570 | | | | | 1594 1619 1644 1669 1694 1720 1746 1772 1798 1824 | | | | | 1850 1877 1904 1931 1958 1986 2014 2042 2070 2098 | | | | | ½ |
| 20 | 1377 1400 1423 1446 1469 1492 1516 1540 1564 1589 | | | | | 1613 1638 1663 1688 1713 1739 1765 1791 1817 1843 | | | | | 1870 1897 1924 1951 1978 2006 2034 2062 2090 2118 | | | | | |
| ½ | 1394 1417 1440 1463 1487 1510 1534 1558 1582 1607 | | | | | 1632 1656 1681 1707 1732 1758 1784 1810 1836 1862 | | | | | 1889 1916 1943 1971 1998 2026 2054 2082 2110 2138 | | | | | ½ |
| 21 | 1412 1435 1458 1481 1505 1529 1553 1577 1601 1626 | | | | | 1650 1675 1700 1726 1751 1777 1803 1829 1855 1882 | | | | | 1909 1936 1963 1991 2018 2046 2074 2102 2130 2159 | | | | | |
| ½ | 1430 1453 1476 1499 1523 1547 1571 1595 1620 1645 | | | | | 1669 1694 1719 1745 1770 1796 1822 1849 1875 1902 | | | | | 1929 1956 1983 2011 2038 2066 2094 2123 2151 2180 | | | | | ½ |
| 22 | 1448 1471 1494 1518 1542 1566 1590 1614 1639 1664 | | | | | 1688 1714 1739 1765 1790 1816 1842 1869 1895 1922 | | | | | 1949 1976 2003 2031 2059 2087 2115 2144 2172 2201 | | | | | |
| ½ | 1466 1489 1513 1537 1561 1585 1609 1633 1658 1683 | | | | | 1709 1733 1759 1784 1810 1836 1862 1889 1915 1942 | | | | | 1969 1997 2024 2052 2080 2108 2136 2165 2193 2222 | | | | | ½ |
| 23 | 1485 1508 1532 1556 1580 1604 1628 1653 1677 1702 | | | | | 1727 1753 1778 1804 1830 1856 1882 1909 1936 1963 | | | | | 1990 2018 2045 2073 2101 2129 2157 2186 2215 2244 | | | | | |
| ½ | 1503 1527 1551 1575 1599 1623 1647 1672 1697 1722 | | | | | 1747 1773 1798 1824 1850 1876 1902 1929 1956 1984 | | | | | 2011 2039 2066 2094 2122 2150 2178 2207 2236 2266 | | | | | ½ |
| 24 | 1522 1546 1570 1594 1618 1642 1667 1692 1717 1742 | | | | | 1768 1793 1818 1844 1870 1897 1923 1950 1977 2005 | | | | | 2032 2060 2087 2115 2143 2172 2200 2229 2258 2288 | | | | | |
| ½ | 1541 1565 1589 1613 1637 1662 1687 1712 1737 1762 | | | | | 1788 1813 1839 1865 1891 1918 1944 1971 1998 2026 | | | | | 2053 2081 2109 2137 2165 2194 2222 2251 2280 2310 | | | | | ½ |
| 25 | 1561 1585 1609 1633 1657 1682 1707 1732 1757 1782 | | | | | 1808 1833 1859 1886 1912 1939 1965 1992 2019 2047 | | | | | 2074 2102 2130 2159 2187 2216 2244 2273 2302 2332 | | | | | |
| ½ | 1581 1604 1628 1652 1677 1702 1727 1752 1777 1802 | | | | | 1827 1854 1880 1907 1933 1960 1986 2013 2040 2068 | | | | | 2096 2124 2152 2181 2209 2238 2266 2295 2324 2354 | | | | | ½ |
| 26 | 1600 1624 1648 1673 1697 1722 1747 1772 1797 1823 | | | | | 1849 1875 1901 1928 1954 1981 2008 2035 2062 2090 | | | | | 2118 2146 2174 2203 2231 2260 2289 2318 2347 2377 | | | | | |
| ½ | 1620 1644 1668 1693 1717 1742 1767 1793 1818 1844 | | | | | 1870 1896 1922 1949 1975 2002 2029 2057 2084 2112 | | | | | 2140 2168 2196 2225 2253 2282 2311 2341 2370 2400 | | | | | ½ |
| 27 | 1641 1665 1689 1714 1738 1763 1788 1814 1839 1865 | | | | | 1891 1917 1944 1970 1997 2024 2051 2079 2106 2134 | | | | | 2162 2190 2219 2247 2276 2305 2334 2364 2393 2423 | | | | | |
| ½ | 1661 1685 1709 1734 1759 1784 1809 1835 1860 1886 | | | | | 1912 1939 1965 1992 2019 2046 2073 2101 2128 2156 | | | | | 2184 2213 2241 2270 2299 2328 2357 2387 2416 2446 | | | | | ½ |
| 28 | 1681 1706 1730 1755 1780 1805 1830 1856 1882 1908 | | | | | 1934 1961 1987 2014 2041 2068 2095 2123 2151 2179 | | | | | 2207 2236 2264 2293 2322 2351 2380 2410 2440 2470 | | | | | |
| ½ | 1702 1727 1751 1776 1801 1826 1851 1877 1903 1930 | | | | | 1957 1983 2009 2036 2063 2090 2118 2146 2174 2202 | | | | | 2230 2259 2287 2316 2345 2374 2404 2434 2464 2494 | | | | | ½ |
| 29 | 1723 1748 1773 1798 1823 1848 1873 1899 1925 1952 | | | | | 1979 2005 2031 2058 2085 2113 2141 2169 2197 2225 | | | | | 2253 2282 2310 2339 2368 2398 2428 2458 2488 2518 | | | | | ½ |
| 30 | 1744 1769 1794 1819 1844 1870 1895 1921 1947 1974 | | | | | 2001 2027 2053 2081 2108 2136 2164 2191 2219 2248 | | | | | 2276 2305 2334 2363 2392 2422 2452 2482 2512 2542 | | | | | ½ |
| | 1766 1791 1816 1841 1866 1892 1917 1943 1969 1996 | | | | | 2023 2049 2076 2104 2131 2159 2186 2214 2242 2271 | | | | | 2299 2328 2357 2387 2416 2446 2476 2506 2536 2566 | | | | | |
| ½ | 1787 1812 1838 1863 1888 1914 1939 1965 1991 2018 | | | | | 2045 2072 2099 2127 2154 2182 2209 2237 2265 2294 | | | | | 2323 2352 2381 2411 2440 2470 2500 2530 2560 2591 | | | | | ½ |
| 31 | 1809 1834 1859 1885 1910 1936 1962 1988 2014 2041 | | | | | 2068 2095 2122 2150 2177 2205 2232 2261 2289 2318 | | | | | 2347 2376 2405 2435 2464 2494 2524 2555 2585 2616 | | | | | |
| ½ | 1831 1856 1881 1907 1933 1959 1985 2011 2037 2064 | | | | | 2091 2118 2145 2173 2201 2228 2256 2285 2313 2342 | | | | | 2371 2400 2430 2459 2489 2519 2549 2579 2610 2641 | | | | | ½ |
| 32 | 1854 1879 1904 1930 1956 1981 2007 2034 2060 2087 | | | | | 2114 2141 2169 2197 2224 2252 2280 2309 2337 2366 | | | | | 2395 2425 2454 2484 2514 2544 2574 2604 2635 2666 | | | | | |
| ½ | 1876 1901 1926 1952 1978 2004 2030 2057 2083 2110 | | | | | 2137 2165 2193 2220 2248 2276 2304 2333 2361 2390 | | | | | 2420 2449 2478 2508 2538 2569 2599 2629 2660 2691 | | | | | ½ |
| 33 | 1898 1924 1949 1975 2001 2027 2053 2080 2107 2134 | | | | | 2161 2189 2216 2244 2272 2300 2328 2357 2386 2415 | | | | | 2444 2474 2503 2533 2563 2594 2624 2655 2686 2717 | | | | | |
| ½ | 1921 1947 1972 1998 2024 2050 2077 2104 2131 2158 | | | | | 2185 2213 2240 2268 2296 2324 2353 2382 2411 2440 | | | | | 2469 2499 2528 2558 2588 2619 2649 2680 2711 2742 | | | | | ½ |
| 34 | 1944 1970 1996 2022 2048 2074 2101 2128 2155 2182 | | | | | 2210 2237 2264 2293 2321 2349 2378 2407 2436 2465 | | | | | 2494 2524 2554 2584 2614 2644 2675 2706 2737 2768 | | | | | ½ |
| 35 | 1967 1993 2019 2045 2071 2098 2125 2152 2179 2206 | | | | | 2233 2261 2289 2317 2345 2374 2403 2432 2461 2490 | | | | | 2519 2549 2579 2609 2639 2670 2701 2732 2763 2794 | | | | | ½ |
| | 1991 2017 2043 2069 2095 2122 2149 2176 2203 2230 | | | | | 2258 2286 2314 2342 2370 2399 2428 2457 2486 2515 | | | | | 2545 2575 2605 2635 2665 2696 2727 2758 2789 2821 | | | | | |
| ½ | 2014 2040 2066 2093 2119 2146 2173 2200 2227 2255 | | | | | 2283 2310 2338 2367 2395 2424 2453 2482 2511 2541 | | | | | 2571 2601 2631 2661 2692 2722 2753 2784 2816 2847 | | | | | ½ |
| 36 | 2038 2064 2090 2117 2143 2170 2197 2225 2252 2280 | | | | | 2307 2335 2363 2392 2420 2449 2478 2508 2537 2567 | | | | | 2597 2627 2657 2687 2718 2749 2780 2811 2842 2874 | | | | | |
| ½ | 2062 2088 2114 2141 2168 2195 2222 2249 2277 2305 | | | | | 2332 2360 2389 2417 2446 2475 2504 2533 2563 2593 | | | | | 2623 2653 2683 2713 2744 2775 2806 2838 2869 2901 | | | | | ½ |
| 37 | 2087 2113 2139 2166 2193 2220 2247 2274 2302 2330 | | | | | 2357 2386 2414 2443 2472 2501 2530 2559 2589 2619 | | | | | 2649 2679 2709 2740 2771 2802 2833 2865 2897 2929 | | | | | ½ |
| 38 | 2111 2137 2164 2191 2218 2245 2272 2299 2327 2355 | | | | | 2383 2411 2440 2469 2498 2527 2556 2585 2615 2645 | | | | | 2675 2706 2736 2767 2798 2829 2860 2892 2924 2956 | | | | | ½ |
| 39 | 2136 2162 2189 2216 2243 2270 2297 2325 2353 2381 | | | | | 2408 2437 2466 2495 2524 2553 2582 2612 2642 2672 | | | | | 2702 2733 2763 2794 2825 2856 2888 2920 2952 2984 | | | | | ½ |
| 40 | 2160 2186 2214 2241 2268 2295 2322 2350 2378 2406 | | | | | 2434 2463 2492 2521 2550 2579 2609 2638 2668 2699 | | | | | 2729 2760 2790 2821 2852 2883 2915 2947 2979 3011 | | | | | ½ |
| | 2185 2212 2239 2266 2293 2321 2348 2376 2404 2432 | | | | | 2460 2489 2518 2547 2576 2606 2635 2665 2695 2726 | | | | | 2756 2787 2818 2849 2879 2911 2943 2975 3007 3039 | | | | | |
| ½ | 2210 2237 2264 2291 2318 2346 2374 2402 2430 2458 | | | | | 2486 2515 2545 2574 2604 2633 2662 2692 2723 2753 | | | | | 2783 2814 2845 2876 2907 2939 2971 3003 3035 3067 | | | | | ½ |
| 41 | 2236 2263 2290 2317 2344 2372 2400 2428 2456 2485 | | | | | 2512 2542 2571 2601 2630 2660 2690 2720 2750 2780 | | | | | 2811 2842 2873 2904 2935 2967 2999 3031 3063 3096 | | | | | |
| ½ | 2262 2289 2316 2343 2370 2398 2426 2454 2482 2511 | | | | | 2539 2569 2598 2628 2657 2687 2717 2747 2777 2808 | | | | | 2839 2870 2901 2932 2963 2995 3027 3059 3092 3124 | | | | | ½ |
| 42 | 2288 2315 2342 2370 2397 2425 2453 2481 2509 2538 | | | | | 2567 2596 2625 2655 2684 2714 2744 2775 2805 2836 | | | | | 2867 2898 2929 2960 2992 3024 3056 3088 3120 3153 | | | | | |
| ½ | 2314 2341 2368 2396 2424 2451 2479 2508 2536 2565 | | | | | 2593 2623 2653 2682 2712 2742 2772 2802 2833 2864 | | | | | 2895 2926 2957 2988 3020 3052 3084 3117 3149 3182 | | | | | ½ |
| 43 | 2340 2368 2395 2423 2450 2478 2506 2535 2563 2592 | | | | | 2621 2651 2680 2710 2740 2770 2800 2830 2861 2892 | | | | | 2923 2954 2985 3017 3049 3081 3113 3146 3179 3211 | | | | | ½ |
| 44 | 2367 2394 2422 2449 2477 2505 2534 2562 2591 2619 | | | | | 2649 2678 2708 2738 2768 2798 2828 2858 2889 2920 | | | | | 2951 2983 3015 3046 3078 3110 3143 3175 3208 3241 | | | | | ½ |
| 45 | 2393 2421 2448 2476 2504 2533 2561 2590 2618 2647 | | | | | 2676 2706 2736 2766 2796 2826 2856 2887 2918 2949 | | | | | 2980 3012 3043 3075 3107 3140 3172 3205 3238 3271 | | | | | ½ |
| 46 | 2420 2448 2475 2503 2531 2560 2588 2617 2646 2675 | | | | | 2704 2734 2764 2794 2824 2854 2885 2916 2946 2978 | | | | | 3009 3041 3072 3104 3137 3169 3202 3234 3268 3301 | | | | | ½ |
| 47 | 2447 2475 2503 2531 2559 2588 2616 2645 2674 2703 | | | | | 2732 2762 2792 2822 2853 2883 2913 2944 2975 3007 | | | | | 3038 3070 3102 3134 3166 3199 3231 3264 3298 3331 | | | | | ½ |
| 48 | 2475 2502 2530 2558 2587 2615 2644 2673 2702 2731 | | | | | 2760 2790 2821 2852 2882 2912 2942 2973 3005 3036 | | | | | 3067 3099 3131 3163 3196 3229 3261 3294 3328 3361 | | | | | ½ |
| 49 | 2502 2530 2558 2586 2614 2643 2672 2701 2730 2760 | | | | | 2788 2819 2850 2880 2910 2941 2972 3003 3034 3065 | | | | | 3097 3129 3161 3193 3226 3259 3292 3325 3358 3391 | | | | | |
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| 50 | 2558 2586 2614 2643 2671 2700 2729 2758 2787 2817 | | | | | 2846 2877 2907 2938 2968 2999 3030 3062 3093 3125 | | | | | 3157 3189 3221 3254 3286 3319 3352 3386 3419 3453 | | | | | ½ |
| | 2586 2614 2642 2671 2700 2728 2758 2787 2816 2846 | | | | | 2876 2906 2937 2967 2998 3029 3060 3092 3123 3155 | | | | | 3187 3219 3252 3284 3317 3350 3383 3417 3450 3484 | | | | | |
| ½ | 2614 2643 2671 2700 2728 2757 2786 2816 2846 2876 | | | | | 2905 2936 2966 2997 3028 3059 3090 3122 3153 3185 | | | | | 3217 3250 3282 3315 3348 3381 3414 3448 3481 3515 | | | | | ½ |
| 51 | 2642 2671 2700 2728 2756 2786 2816 2845 2875 2905 | | | | | 2935 2965 2996 3027 3058 3089 3120 3152 3184 3215 | | | | | 3248 3280 3313 3346 3379 3412 3445 3479 3512 3546 | | | | | ½ |
| 52 | 2671 2700 2728 2757 2786 2816 2845 2875 2905 2935 | | | | | 2965 2995 3026 3057 3088 3119 3150 3182 3214 3246 | | | | | 3279 3311 3344 3377 3410 3443 3476 3510 3544 3578 | | | | | ½ |
| 53 | 2700 2729 2758 2786 2816 2845 2874 2904 2934 2965 | | | | | 2995 3025 3057 3087 3118 3149 3181 3213 3245 3277 | | | | | 3310 3342 3375 3408 3441 3474 3508 3542 3576 3610 | | | | | ½ |
| 54 | 2729 2758 2787 2816 2845 2875 2904 2934 2964 2995 | | | | | 3025 3056 3087 3118 3149 3180 3212 3244 3276 3308 | | | | | 3340 3373 3406 3439 3472 3506 3540 3574 3608 3642 | | | | | ½ |
| 55 | 2758 2787 2816 2846 2875 2905 2934 2964 2995 3025 | | | | | 3055 3086 3118 3148 3179 3211 3243 3275 3307 3339 | | | | | 3372 3405 3438 3471 3504 3538 3572 3606 3640 3674 | | | | | ½ |
| 60 | 2788 2817 2846 2876 2905 2935 2964 2995 3025 3055 | | | | | 3085 3117 3148 3179 3210 3242 3274 3306 3338 3371 | | | | | 3404 3437 3470 3503 3536 3570 3604 3638 3672 3707 | | | | | |
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## ON THE APPLICATION OF SCULPTURE AND SCULPTURED ORNAMENT TO ARCHITECTURE.

By H. B. Garling.

At a meeting of the Royal Institute of British Architects, held on the 29th of May, the following paper was read:—"*Essay on the Application of Sculpture and Sculptured Ornament to Architecture, and the Principles which should regulate their introduction into Buildings generally, both with regard to Beauty of Embellishment and Propriety of Style.*" By Mr. H. B. Garling; for which the Silver Medal of the Institute was awarded.

If from the study of some individual branch of fine art, we proceed to consider how to combine any two or more of them in the same composition with the greatest effect,—in investigating the relation they bear to each other, the means by which the impressions conveyed by the one are influenced by its connection with the other, and the sources from whence our ideas of beauty or grandeur in each department result, we cannot fail to remark the close and striking analogy which exists between all the various branches into which fine art is divided, whether by the impressions they produce upon the mind, or the means by which those impressions are effected. We shall find that though varying in the organ by which they address the imagination, or the vehicle by which they convey their impressions to the mind, they influence the same feelings, strike as it were the same chords, and depend upon causes varying in form only, to produce effects substantially the same.

Whether it be architecture or sculpture, painting, music, or poetry that engages our attention, it is but the expression of one and the same sentiment—the collecting and arranging in the most effective manner, the giving form and substance, as it were, to those ideas and images, from which result our impressions of the sublime and beautiful.

Though we may discover in all, this common origin and aim, yet between some the connection is obvious; and the assistance they afford to each other, when skilfully combined, more natural and effective.

Thus, if to the symmetry and proportion of architecture we add the graceful terminations and flowing lines of sculpture, or the relief and rich variety of pictorial embellishments, we enhance the value of each by placing it in its most effective position, and surrounding it with suitable and appropriate accessories.

To the artist it is, therefore, an important as well as an interesting investigation to consider how the architect and sculptor may unite their labours with the most successful result; and what rules we must observe in the treatment of each department to produce a harmonious and effective combination.

If we commence our investigation by tracing the distinguishing features of the various styles of art as each rose in succession from the materials bequeathed by its predecessor, the first that engages our attention is the collossal architecture of the Egyptians. The distinguishing features of these extraordinary edifices are so well known as scarcely to need description: interesting as they may be to antiquarian research, and rich in matter for reflection and speculation on other points, to the artist they afford but scanty materials for study, and still less for imitation and example. That the germs of beauty and proportion may be traced in a certain propriety of decoration and regular disposition of parts may not, perhaps, be denied; as also that a certain effect of grandeur has been attained; the results of collossal size both in the general mass, and also in the details of the composition. Yet they exhibit a style of art so circumscribed in its object, so limited in its resources, and so much fettered by conventional ideas and principles, as to limit its advancement beyond a certain point—forming, in fact, a perfect reflection of the social condition of the people with whom it originated.

If from Egypt we turn to Greece (where exquisite refinement of taste and feeling were combined with a social condition more favourable to progress than in the former country), we shall find the powers of the artist rapidly increasing with the demand for their employment, and the scope afforded for their exercise. Aiming at the attainment of beauty by nicely-adjusted proportions and propriety of decoration, and attaining grandeur and dignity of effect, not by actual size, but by simplicity of parts and regularity of design, we observe even in their earliest efforts the germs of that perfect mastery of all the resources of art, which subsequently ripened and expanded into the inimitable productions of the age of Pericles.

Apart from the merits of each in its particular department, the principles they observed in combining architecture and sculpture in one composition claim our most careful attention. Whether forming the graceful terminations of the acroteria, or filling up the voids of the pediments, or metopes of the Doric entablature, or decorating the walls in long continuous friezes of elaborate design, we observe how admirably the sculptural accessories complete the general outline of the masses, fill up every void space with rich and appropriate decoration, and relieve the more regular forms of the architecture with the most pleasing variety of lines; imparting poetry of feeling to the whole composition, and assisting in a most important degree the character aimed at by the architect.

The rules observed in the treatment and distribution of sculpture by the artists of Greece, obtained throughout the whole of the best period of classic art.

The triumphal and monumental buildings of antiquity are particularly interesting, as exemplifying the views and ideas of artists of the most acknowledged skill and judgment. The mausolea of Halicarnassus, of Hadrian, and of Augustus, the Antonine and Trajan columns, the triumphal arches on the Via Sacra, the commemorative monuments in short of every class, when carefully considered, will be found to possess a character admirably adapted to the purposes of their erection: but in the application of these ideas to our own times, we must ever keep carefully in view the particular circumstances which guided them in the forms and arrangement they adopted. As art degenerated towards the decline of the Roman empire, the abandonment of true principles became apparent in all its departments—in none more so than in the treatment of sculptural accessories,—their meretricious character and the profusion of ornament (often exceedingly coarse and inelegant) destroying that repose and chaste simplicity, so essential to true dignity of style and so happily attained in the works of a better period. Of these abuses the latter examples of Roman architecture, particularly the baths and even to a greater degree the gorgeous remains at Balbec and Palmyra, afford remarkable instances.

The political convulsions which for centuries distracted the world, so completely buried in barbarism and ignorance every class of literature and every vestige of art, that scarcely any production worthy of the name can be recorded. This destruction of art seems to have been completed at a period when the true principles of taste being abandoned, and its most essential rules being completely lost sight of, all hope of further progress was stayed; and thus, though for a time its extinction was most complete, this very circumstance may be said to have paved the way for its regeneration on better principles, at a subsequent period. By it was annihilated all mere conventional rules, and by it was destroyed every false standard of excellence; and the absence of precedent compelled the artist to go back to the study of nature, the only source from which, in early ages, he can, and in all ages, he should, derive his ideas, however he may seek to form his taste, mature his judgment, or collect experience from the works of others: and from this constant reference to nature alone, we must trace that freshness of feeling and vigour of conception with which the early productions of art and literature teem, and which we strive in vain to catch when the feelings of society have become more refined and enervated, and its structure more artificial and complicated. Art will invariably take its tone and expression from the character of the age in which it is produced; it is an influence the artist cannot resist; it forms the very atmosphere he breathes; and from it the constitution of his mind takes its tone: the experience of the past offers no exception, the character of art at the present day confirms it.

As the arts gradually emerged from the obscurity in which they were buried (fostered by a patronage peculiarly favourable for the development of their loftiest powers), they began to assert their true position and exercise their legitimate influence on society; and while the monuments of classic art were rapidly falling to decay, another style of architecture arose, based on principles of construction and of composition almost as diametrically opposite to those of classic art as the source from whence it sprung, the purposes to which it was dedicated, and the character of the age and people amongst whom it originated. The sculptural accessories are no less different in character than the architecture with which they are associated. These sculptural accessories (often vigorous in design and well conceived, consisting principally of isolated figures, stiff and constrained, distributed and arranged rather by conventional and prescribed ideas of symbolism than by rules of artistic composition), convey ideas more by symbolical arrangement than by a combination of action and expression; of this perhaps the fronts of Wells and Exeter Cathedrals may be adduced as the most striking examples. Thus in the sculptural decoration of mediæval architecture we observe a style of art too subordinate in

its character, too circumscribed in its views, and too much fettered by conventional forms to expand and assert an independent position; aiming solely at the expression of devotional feeling by the adoption of the most simple forms. These remarks do not apply to the artists of the revival in Italy; who, forming their taste on the model of the antique, united to these sentiments the lofty expression of intellect and ideal perfection; and thus produced a distinguishing merit and charm in their works. In the revival of the classic styles in Italy, we, in the treatment of the two arts of architecture and sculpture, meet with the observance of the same principles which guided the artists of classic times; but not, however, carried out with the same refinement of feeling and correctness of taste. The vigorous and fertile imagination of the great Italian masters (though it enabled them to trace out their own path, and to imitate the example and catch the feeling without tamely copying their model) often betrayed them into irregularity, which marred the effect of their most successful works; while by artists of inferior talent, exaggerated action and expression, eccentricity, and extravagant conceits, were too often confounded with the bold originality and vigorous conceptions of true genius. Of these defects the palaces and churches of Italy afford innumerable instances, which will immediately occur to those acquainted with the works of these masters. It cannot, indeed, be denied, that the peculiar character of the Italian style admitted a freedom of treatment in the sculptural accessories which would be offensive and inadmissible in more correct and regular compositions; but at the same time it will be obvious that there is a limit to these irregularities, which can only be assigned by good taste and discriminating judgment on the part of the artist himself.

The first and most important point is to observe a perfect accordance in style and character with that of the building to which we apply it, that it not only should illustrate its object and purpose, by intelligible and appropriate allegory, but convey it also with congruity of feeling and sentiment, even to the minutiæ of execution, (for the skilful architect not only adapts the main features of his building to the purpose for which it is designed, but also expresses it in every member, and moulds every detail in exact accordance). But to produce that harmony and propriety (which is the source of our most agreeable sensations in contemplating the productions of art), we must in addition, distribute it so judiciously through the composition, and so nicely adjust it in proportion and position, that it shall appear an integral portion of the design,—the work as it were of one hand, and so completely the expression of one idea, that a chasm and void would be created by its removal: that neither by disproportionate size, nor too prominent a position, it should obtrude offensively on the eye; nor by the opposite extreme, appear to retire too much and lose its legitimate effect and place in the composition. The regulation and nice adjustment of these points cannot, however, be determined by rule, since every individual case will require a different treatment, but it must altogether be attained by that refinement and correctness of taste on the part of the artist which can only result from a careful and accurate study of the best models, united with the greatest judgment and discrimination.

As a subordinate and purely decorative feature, it will be of the utmost importance that the outline of the sculpture should be regulated by, and accord most accurately with, that of the architecture; and that it fill up with precision those circumscribing lines within which it is placed; that there be no protuberance, undue projection, or ungraceful deflection in the contour, either in itself, or in combination; and that it do not interfere with, or break off those main lines which indicate the constructive features of the building, or the continuity of which expresses the arrangement and proportions of the composition.

It will also be found a point of considerable importance, in combining sculpture with architecture, to adopt a sober and subdued style of composition in the position and arrangement, and particularly in the treatment, of the draperies and accessories, not only in isolated figures and in those which form the terminations and crowning members, but also in the composition of the friezes and pediments. The confusion produced by exaggerated action or intricate grouping will be immediately detected by its discomposing and harshly contrasting, without relieving the lines of the architecture; though on the other hand must be avoided a meagre and straggling arrangement, and the stiff effect arising from perpendicular and horizontal lines. The value of sculpture as a decoration (independent of the sentiment it conveys) consists much in the relief it affords by carrying up the eye with its graceful terminations; filling up what would otherwise be void and blank, with varied and undulating lines and forms of the most exquisite beauty. The success with which the artists of Greece moulded and adapted these requirements will prove that, when properly treated, they tend neither to cramp the ideas nor to shackle the invention of the artist.

If it be necessary to observe these rules in the treatment of groups, it will be found still more so in the case of isolated figures; and the infringement of them produces still more ungraceful effects. On the revival of art in Italy, distortion and exaggerated action and expression were too frequently confounded with originality and vigour of execution; and we are continually meeting in their works with the most striking instances both of the infringement of these rules and the ungraceful effects resulting therefrom.

In placing sculpture in juxta-position with architecture, it is obviously a point of no small importance to consider the scale thereby imparted to the composition. It will hardly be necessary to demonstrate with argument, that with which every artist must be acquainted; viz., that magnitude is relative rather than actual, and that by skilfully proportioning details, or by placing in juxta-position features, with the size of which, by habit, experience, or instinct, we are acquainted, with those of which we have no other data for determining the magnitude, he can impart a fictitious scale to his composition; or that by diminishing one feature and exaggerating another, he can, by this comparison, produce an idea of magnitude which the actual size does not possess. In practice, this, nevertheless, has but too frequently been lost sight of; and in many instances, where circumstances institute the comparison, it has been rather the result of accident than design. Perhaps this remark might be more justly restricted to the revival and later productions of art; since, in the works of the antique, we continually observe not only its application, but the success with which it has been attended. The principle must, however, obviously become of peculiar importance in the case of sculpture, since the proportion of the human figure is that with which we are most naturally and necessarily acquainted, and one which we perhaps more readily apply than any other (adjusting everything to this scale instinctively), and although, to a certain extent, the scale of the sculptural accessories, particularly the isolated figures, will be indicated by various circumstances in the proportions of the architecture, it is not absolutely or invariably so, and the advantage to be gained by skilfully adjusting this scale must never be lost sight of. When, by being in due proportion to the members of the architecture, it would become too colossal, it might be preferable to adopt a different species of decoration; since, where the ordinary features of the composition are merely increased in actual size, and the same relative proportions observed, the scale by which we measure is increased in nearly the same ratio. We may also observe, that the undue exaggeration of the human figure beyond its natural proportions, so far from invariably producing an effect of grandeur, is sometimes productive of impressions akin to those resulting from actual deformity; the proportioning these parts is, however, a point which must depend solely upon the judgment of the artist, and one for which no rule can be laid down: a careful study of the best models and an accurate observation of works already executed, will form the best and perhaps the only guide.

When we observe how necessary to produce a pleasing and harmonious effect (even in isolated works, which are to be considered as complete in themselves and not affected by external circumstances) are the duly balancing the corresponding parts of the composition; the skilfully contrasting and combining forms and lines of varying contour; the duly filling-in and adjusting every part so as to give one outline to the mass, however varied in detail,—it is obvious, that in combination with architecture, the slightest discrepancy or failing in this respect will be exaggerated, by contrast with the regularity of the lines and masses with which it is associated; and to this point, therefore, the artist must direct his most diligent attention.

In designing groups and figures which crown and form the termination of the composition, it will be found of the greatest importance that the figures in every aspect appear in perfect equilibrium, and firmly planted and balanced on the pedestal on which they stand, devoid of any protuberance or projection, either in limb or drapery, which may appear to throw the mass more on one side than on the other. It will for this purpose be found necessary carefully to study the work from every possible point of sight from which it can be seen; since we have continually to observe that though perfect when viewed in some positions, this due equilibrium of the mass is disturbed when seen in others, and that even, when, in reality and mechanically speaking, it is duly poised.

Of the ill effects resulting from an imperfect or partial study of

this important point, the works of the artists of the revival above alluded to (though masters of perspective and perspective effects) afford innumerable instances; while of consummate skill and science in meeting these requirements, the inimitable productions of the Grecian chisel afford at once a most striking example, and to the artist an invaluable model for study.

An important part of the subject of the application of sculpture to architecture is the employment of caryatides in the place of the column to support the entablature of the orders. Whether the origin of this feature be that related by Vitruvius, or whether it resulted merely in the fertile and lively imagination of the artist adopting this form for variety only, it will hardly be worth our while to consider; though the employment of the human figure combined with massive columns, but not aiding in the support of the mass above, occurring in the Egyptian temples, might induce the belief that the idea has been already suggested by precedent, aud that the character it assumed in Grecian architecture was merely the result of the more refined taste of the artist. The instances in which they were employed, and the manner in which they have been treated, has been already considered, as also that of the same feature by the artists of the revival in Italy. It has elsewhere been but very sparingly adopted. Jean Goujon has left us some admirable specimens of his taste and skill in the Louvre at Paris, which exhibit all the chaste and refined feeling of the antique combined with the freedom of the revival. Inigo Jones's circular court of caryatides, in the Palace at Whitehall, though not executed, yet forms so beautiful a feature in the design that we must not omit to notice it, and to observe with what peculiar judgment the architect has treated this feature of his design: by applying it to an interior court, a perfectly unique effect is preserved, undisturbed by comparison in size with the columnar arrangement.

It is obvious that, in a great measure, the same rules will regulate the treatment of caryatides which govern the application of sculpture generally to architecture; viz., a general sobriety of treatment; the avoiding all strained and unnatural positions of the limbs; no flutter or discomposure of the drapery; the figure balancing itself most accurately, and appearing in every position in the most perfect equilibrium; the outline of the limbs being clearly developed through the folds of the drapery; and, lastly, the absence of the idea of forced and laborious exertion on the one hand, and of positive inaction on the other, that the figure appear easily and naturally to support its superincumbent members, and that they be so treated that the same outline and position do not recur too often. If engaged with the wall, as is frequently the case, a greater freedom of treatment may undoubtedly be adopted, since the outline of the figure will not vary much in different points from which it can be seen.

It might at first be supposed that the study and practice of two arts, so intimately connected with each other, and so naturally and readily combined, might have been united with advantage in the same artist. If, however, we look back upon the history of art, more particularly to the era of the revival in Italy, at which time they were not uncommonly united in the same individual, we cannot but observe that the abuses and deformities are principally to be met with in the works of the architect-sculptors; and that in artistic effect and arrangement, as well as in appropriate and characteristic detail, they were surpassed by their brethren, the architect-painters of the same period. However, they both fall short of those whose whole attention was devoted to architecture alone; showing, more conclusively than argument, that the rules of the artist must, in these points, be his *non imperitus;* that to compass more than one to its fullest extent—to attain to or approach perfection, where the attention is divided upontwo objects of equal importance and scope,—is beyond the grasp of the most powerful intellect, and that the attempt can only be attended with failure in one, or mediocrity in both. There may be quoted a few brilliant exceptions; yet, if these even be fairly balanced upon their own merits, irrespective of the authority of great names, the observation may apply to them.

In conclusion, although it might seem that the rules to be observed in applying sculpture to architecture are rigid, and calculated to trammel the artist with restrictions incompatible with the free exercise of his genius, there is, in reality, perhaps no point on which the invention of the artist is less fettered, or on which so wide a field is left for the exercise of his own discretion, since they determine no fixed proportions, prescribe no particular form, arrangement, or detail, and their very application must depend on the artist's discernment and taste. How little these rules are calculated to induce poverty and tameness of design, or confine the free exercise of the imagination, the example of the gifted artists of Greece will sufficiently prove. The rules of art, so called, are not arbitrary restriction founded on the caprice of fashion, the authority of precedent, or the practice of approved masters,—but those immutable laws, upon the observance of which beauty, grandeur, and harmony most depend (which admit of no exception), apply to every variation of circumstances; are ascertained by an accurate observation of the effects of certain combinations; and are as inseparably connected with the productions of certain results as cause and effect in mechanical appliances in the physical world. It is the attribute and characteristic of true genius intuitively to know, and instinctively to apply them, however necessary experience, careful observation, and diligent study may be to mature the judgment and refine the taste. To conform to them will exercise its ingenuity rather than restrict its powers, while their due observance will give force and precision to its efforts, by directing them in the right channel, and by preserving it from those irregularities which mar the productions of genius unaided by experience and education.

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## RESISTANCES TO RAILWAY TRAINS.

### EXPERIMENTS DOWN INCLINED PLANES BY GRAVITY.

Some experiments have recently been made on the retardation of trains on inclined planes; and as the subject has been much debated, a brief analysis of the results may be acceptable,—an account of the experiments themselves will be found at the end of this paper. It is to be observed, that the circumstances under which they appear to have been conducted, render uniformity and certainty in the conclusions from them very difficult, or rather absolutely impossible.

In the first place, to get a *general law* of resistance by experiments on inclined planes, it is absolutely requisite that the line should be straight, the air calm, and the distance traversed considerable. Of the resistance of curves, and wind in motion, nothing can be known till the resistance in more simple cases be ascertained. To begin with the more complex enquiry is to entangle the subject with phenomena, respecting which ignorance virtually is confessed, by the very circumstance of making the experiment.

Again, it is imperatively necessary that the distance traversed should be considerable—and we urge this point the more strongly, because it applies, not only to the present experiment, but also to former experiments on the narrow-gauge railways. The report to the British Association on Railway Resistances (1837) contains the following important remark on this head:—

"In every case hitherto examined, the uniform velocity which may appear to have been attained under such circumstances, is somewhat less than that attained on the same plane, when the train has commenced the descent at a considerable velocity; it may therefore be doubted, if trains which may appear to have attained an uniform velocity after starting from a state of rest (on planes on which the experiments have been made), may not really be travelling at a very slowly accelerating velocity, and as the lengths of such planes of one inclination do not enable this to be ascertained with certainty, it has been deemed better to exclude such results. The same rule has been followed for similar reasons in analysing the other series of experiments on inclined planes referred to in this paper."

This remark appears to apply to the experiments before us, and also to those undertaken by Mr. Wyndham Harding, on the Croydon Atmospheric Railway. Of course, it is only where the mass or the train is small, that the resistance soon begins to *tell;* the effect of the inertia of large trains travelling at high velocities, is best seen by considering the distance they will move when subject to the enormous pressure of the break.

The present experiments being subject to these various sources of error, exhibit discrepancies which greatly diminish the value of the conclusions indicated. For instance, in each of the first nine experiments (except the 6th and 8th, which may be altogether disregarded on account of the disadvantageous circumstances under which they were conducted), there occurs a sudden and unexplained increase of velocity at the distance 85½. This may, perhaps, be attributable to local circumstances; but what is more important, is the fact that the alteration of the gradient from $\frac{1}{100}$ to $\frac{1}{600}$, makes no perceptible alteration of the speed in five out of the seven trustworthy experiments on those gradients. This consideration furnishes a convincing proof of the danger of drawing deductions from the *apparent* uniformity of motion for short distances. If the resistance in pounds per ton for a given velocity

be deduced from the apparently unaltered motion on *both* gradients, we arrive at the absurdity of giving the resistance two different values, of which one is between six and seven times as great as the other.

To exhibit more clearly the very great effect of the inertia of trains in maintaining their velocity, we will calculate the motion on level ground, at a uniform resistance of 20 lb. per ton, when the train is started at a velocity of 80 feet per second (or rather more than 54 miles an hour). By the principle of Conservation of *Vis Viva*—

$$\tfrac{1}{32} W (V^2 - v^2) = 2 R x;$$

where R is the uniform resistance, V the initial velocity in feet per second, $v$ the velocity at a subsequent time when the train has travelled $x$ feet, W the weight, and therefore $\frac{1}{32}$W the mass (putting 32 feet for the measure of gravity): or *one thirty-second part of the weight × by the difference between the squares of the initial and subsequent velocity, is equal to twice the corresponding distance traversed × by the uniform resistance.* This is a simple arithmetical rule for calculating *all* cases of the rectilineal motion of a body started with a given initial velocity, and then abandoned to the influence of a constant retarding force.

To suit the present case, we put V = 80, and the resistance = 20 pounds per ton, and multiply the weight of the train by 2240, to express it in pounds; and the above formula becomes

$$\frac{2240}{32} (V^2 - v^2) = 40 x; \text{ or, } 11{,}200 - \frac{7}{4} v^2 = x,$$

to find the distance in feet corresponding to any subsequent velocity. Putting $v = 0$, we find that *the train moves 2·12 miles before it comes to rest;* and putting $v = 70$, we find that *the train moves 2,925 feet, or more than half a mile, before its velocity is reduced from 80 to 70 feet per second.* If, instead of making the resistance uniform, we supposed it to decrease gradually, as it does on railway, the distances above calculated would be increased.

These considerations show the absolute necessity of using long distances in performing experiments on the retardation of trains. But though they throw a doubt on the experiments before us, it would be too much to say that they render them absolutely worthless. On the contrary, with some exceptions, the conclusions display a certain degree of consistency which adds to their weight. Of course, the testimony inferred from this consistency would be much greater if we were informed that these experiments are *all* that have been undertaken, and that none other inconsistent with them have been performed.

Now, of the experiments on the $\frac{1}{100}$ gradient, the 2nd, 3rd, and 5th, with an initial velocity of 50 to 52 miles an hour, exhibit tolerably uniform velocities. This would indicate that at 50 to 52 miles an hour, the resistance is $\frac{1}{100}$ the weight, or 22·4 lb. per ton. Experiments 1, 4, and 7, show retarding velocities, indicating that at 54 to 58 miles an hour, the resistance exceeds 22·4 lb. per ton. Again, in the 13th experiment, on a gradient of about $\frac{1}{85}$, the speed is tolerably uniform; in the 11th, on the same gradient, it is accelerated. In both experiments on a gradient of $\frac{1}{120}$, the speed is accelerated. Reasoning as before, we have—on the assumption that the above form of the data is accurate—the following general conclusions, in three pairs, corresponding with the three gradients:—

| | miles per hour. | | lb. per ton. |
|---|---|---|---|
| When velocity is | 50 – 2 | Resistance equals | 22 |
| | 54 – 8 | exceeds | |
| | 55 | equals | 26 |
| | 43 | less than | |
| | 36 | less than | 19 |
| | 37 | less than | |

These results agree very well with those obtained in 1846, by Mr. W. Harding, by the dynamometer, on the South Eastern narrow-gauge railway, and reported in his paper presented to the Institution of Civil Engineers:—

| | miles per hour. | | lb. per ton. |
|---|---|---|---|
| Velocity | 29 | Resistance | 16·5 |
| | 37 | | 18·3 |
| | 45 | | 21·7 |
| | 46 | | 21·3 |

To complete the comparison, we select those of the experiments of the British Association which were made at velocities above 30 miles an hour, on inclined planes on narrow-gauge lines:—

| | miles per hour. | | lb. per ton. |
|---|---|---|---|
| Velocity | 31 | Resistance | 23·4 |
| | 34 | | 23·4 |
| | 37 | | 25 |
| | 32 | | 22·5 |

It is to be observed, that these rates of resistance considerably exceed the former.

We do not bring into the comparison the experiments of the Gauge Commission, in which the resistance is derived from the consumption of water by such an arbitrary and dangerous process, that we feel justified in rejecting that evidence entirely. Neither can Mr. Wyndham Harding's experiments on the Croydon Atmospheric Railway, by the difference of barometric pressures, be admitted into the comparison. *His case for the rapid increase of resistance with increase of speed, rests almost entirely on these experiments,* and therefore, as we think, on an insufficient foundation. These experiments are as follows:—

| | miles per hour. | | lb. per ton. |
|---|---|---|---|
| Velocity | 61 | Resistance | 52·6 |
| | 53 | | 41·7 |
| | 55 | | 36 |
| | 50 | | 32·9 |
| | 47 | | 33·7 |

In the first place, the results obtained by the barometer are inconsistent with themselves: the resistance at 55 miles an hour is fifteen per cent. *more* than at a *less* velocity of 53 miles. The only experiment at upwards of 60 miles an hour, shows an increase of resistance so disproportionate, as naturally to induce suspicion;—at all events, a *single* result, so inconsistent with all previous observation, ought not of itself to be sufficient evidence of a general law. Moreover, this very experiment was conducted under circumstances most unfavourable to a general conclusion. The distance traversed was 3½ miles, the time of transit four minutes and a half, and the recorded velocity fluctuated from 32 to 61 miles. And yet this SINGLE trial is the mainstay of the theory of high resistances at high velocities! We have already shown the great effect of the inertia of trains at high velocities, and the extreme uncertainty of any conclusions from the *apparent* uniformity of motion;—that the uniformity is apparent only and not absolutely certain, the brief duration of the experiment and its great fluctuations are sufficient testimony.

It is important to observe, in confirmation of this view of the subject, that the barometric method of calculating resistances, always gives results which, as far as they can be compared, exceed those obtained by any other method.

On the whole, we are inclined to an opinion, from the insufficient evidence before us, that the resistance does not increase so much with the velocity as has sometimes been contended; and that the resistances per ton, do not differ widely on the broad and narrow gauge. The advantage, if any, belongs to the former; principally, we imagine, on account of the comparative smoothness of motion over longitudinal sleepers. There can be no reasonable doubt, that comparing the longitudinal and transverse sleepers, when both are in perfect order, the former, by giving more perfect support to the rails, render them less liable to vibration and concussion. It may be laid down, as a general rule, that whatever increases the regularity of motion, diminishes the resistance. One of the consequences of this rule is, that the resistance of trains is diminished by diminishing their lateral oscillation. On this subject we have not space to speak at length; it is sufficient to observe, that the tendency to oscillate depends on what is known in mathematics as the *radius of gyration*, and is therefore diminished by diminishing the weight projecting beyond the wheels outside, and by reducing the proportion of the height of the centre of gravity to the distance between the points of support.

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[*Abbreviated from the "Morning Herald."*]

We return to the consideration of this interesting and important practical railway investigation. As we have previously stated, the question of the "resistances to railway trains at certain velocities," is not a mere scientific question, but one in which the convenience and accommodation of the public are very materially involved. The establishment of the truth of the "*formula*" which makes the resistance, at 60 miles per hour, some 40 lb. per ton, or 50 per cent. higher than we shall presently show it to be, would present a strong *economical* argument either *against* express travelling, or *for* the restriction of the accommodation of quick transit to first-class passengers at high fares.

In the observations made by us a few days since, in reference to the extraordinary differences of opinion existing on the subject between practical engineers, we noticed the singular fact that while a uniform velocity of not more than 36 miles per hour has ever been maintained with narrow-gauge trains, by the force of gravity, down an incline of 1 in 100, a uniform velocity of upwards of 53 miles per hour had been maintained with broad-gauge trains by gravity down an equal incline. We then stated that we had ourselves gone done the Box Tunnel incline (1 in 100) at a greater uniform velocity than 53 miles per hour. We have since made a series of experiments down the Wootton Bassett incline, stated to be 1 in 100, but some portion of which is 1 in 110 only; and down other inclines on the Bristol and Exeter Railway; and from the details given below, it will be seen that a

much greater uniform velocity than 53 miles per hour, even under *very unfavourable circumstances*, can be obtained down 1 in 100, by gravity; and that consequently the foundation on which many railway engineers have rested the very pillar of their theory of high rates of resistance at high velocities, is utterly without substantiality,—that, indeed, it is a mere fallacy, which will hereafter be numbered amongst the delusions and visions of practical men.

The whole of the following experiments were made with ordinary working trains, and the object was not to collect minute data from which any scientific results might be deduced, but simply to prove—exclusive of the results of experiments made by either broad or narrow gauge engineers—that what has long been considered an "*established fact*" in reference to the resistance to railway trains descending inclined planes by force of gravity, is a mere "circumstance," which, although applicable to narrow-gauge trains, is utterly inapplicable to broad-gauge trains. The diversities in the rates of speed shown in the workings given below arose, no doubt, from a great variety of causes. Nearly the whole of the portions of the line over which the experiments were made consists of a series of curves, and of cuttings and embankments. The carriages were of different weights, and may occasionally have been well or badly coupled. One day the weather was calm, the next it was unsettled; in some of the experiments there was a slight head wind, in others a moderate side wind from the right, or a moderate side wind from the left prevailed, and during three of the experiments there was a brisk side wind. The speed, too, at which the trains were running when the steam was shut off would, in relation to the weights of the carriages, as well as to the direction of the wind, enter into the causes of these diversities of speed. We shall, however, not hazard a single opinion on these matters, but confine ourselves to demonstrations that the "*formula*" of high resistances at high velocities is worthless in respect of the resistance sdue to broad-gauge trains descending inclined planes by their own gravity.

In the experiments made down the Wootton Bassett incline with the dynamometer carriage, constructed under the directions of Mr. Brunel, the carriages were weighed to 10 tons each. In no one of the experiments given below, which were made with the ordinary passenger trains, did any of the carriages amount to this weight—that is, they were not full of passengers. The engines employed belong to an old class, and weigh, road-worthy, about 23 or 24 tons.

It has been objected against the experiments made down the Wootton Bassett incline with the dynamometer carriage, that the distance over which a uniform or increasing velocity was attained, viz., 10 or 11-16ths of a mile, is too short to produce a useful practical result. To meet this objection we took the rates of speed not only down the mile and one-eighth of the fall of 1 in 100, but down the next seven-eighths* of a mile, which are on a fall of 1 in 660 only. The fall of 1 in 100 commences a few chains beyond the 85th mile-post, and terminates a few furlongs† beyond the 86¼th mile-post. Thence to the 86¾th mile-post, the fall is 1 in 660.

The *first* experiment was made with a train consisting of four passenger-carriages, three horse-boxes, and one luggage van, weighing about 60 tons. The engine was the "Orion." The table gives the working for the quarter mile immediately preceding the 85th mile-post, as well as from the 85th to the 86¾th mile-post. The rails were dry, and very little wind was stirring.

It will be seen that the speed for upwards of half-a-mile down 1 in 660 is very little below the uniform velocity down nearly three-quarters of a mile of 1 in 100. We merely record the fact, leaving those who have more time at their command than we have ourselves to explain or suggest the causes.

The *second* trip was with a train of four passenger-carriages and a horse-box, weighing about 41 or 42 tons, and was attached to the "Mars" engine—rails dry and weather calm.

The *third* trip was with the same engine, with three passenger-carriages, one luggage-van, and two horse-boxes, weighing about 45 or 46 tons.

The *fourth* experiment was made with the "Firebrand" engine. The train consisted of three passenger-carriages and a luggage-van, weighing about 36 tons. The carriages were well filled with passengers.

The *fifth* experiment was with the "Orion," with four passenger-carriages, three horse-boxes, and a luggage-van, weighing about 59 or 60 tons. The steam was not shut off in this case until the engine was within a few chains of the 85¼th mile-post.

The *sixth* experiment was with the "Load Star." The train consisted of four passenger-carriages and a luggage-van, weighing about 41 or 42 tons. A brisk side wind was blowing. It will be observed that the rates of speed alternate over the whole extent of the 2¼ miles.

The *seventh* trip was with the "Arab," with a train consisting of three passenger-carriages and a luggage-van, weight about 38 or 40 tons—carriages well filled. In this trip we obtained the greatest uniform velocity—rails dry; weather calm.

The *eighth* experiment was with the "Bellona," with four passenger-carriages and a luggage-van, weighing about 41 or 42 tons.

A brisk side wind prevailed on this occasion, and the same result was produced as in the previous experiment, where a side wind affected the train, viz., alternating rates of speed.

The *ninth* experiment was with the "Firebrand," with a train of four carriages and a luggage-van, weighing about 45 or 46 tons—rails dry; slight side wind.

* Qy. seven-sixteenths. † Qy. chains.

The *tenth* experiment was upon the Bristol and Exeter line from the 174th to the 176¼th mile-post. This portion of the line is on a fall of 45·75 feet per mile, or about 1 in 120. The engine employed was the "Load Star," and the train consisted of four passenger-carriages and a luggage-van, weight about 41 or 42 tons. The descent was commenced at a speed of about 36 miles per hour—rails dry, and slight head wind.

In this experiment the velocity down an incline, less by 20 feet per mile than that down which the narrow-gauge trains have never yet maintained a uniform velocity of more than 36 miles per hour, increased from 36·3 to 42·4 or 6·1 miles per hour. And yet we have little doubt we shall still find *practical* men contending for the high rates of resistances which some of the narrow-gauge party pertinaciously assume to be due to *all* railway trains travelling at high velocities.

The *eleventh* experiment was from the 172¾ to the 170¾—viz., two miles. The engine employed was the "Saturn," and the train consisted of five passenger-carriages and a luggage-van, weighing about 56 or 57 tons. For about two-thirds of a mile the fall is 1 in 82; this is followed by a fall of about 6 chains of 1 in 90, and another fall of about 7 or 8 chains of 1 in 82. The rest of the distance is on a fall of 1 in 90. The average velocity of the train through the White Ball Tunnel, 49 chains in length, and which immediately precedes the inclines over which we took the working of the train, was 42·5 miles per hour. It will be seen that this speed was increased to 50 miles an hour at the 170¾th mile-post.

The *twelfth* experiment was a second run down the 1 in 120, between the 174th to the 176¼th mile-post. The engine employed was the "Firebrand," and the train consisted of four carriages and a luggage-van, weighing about 44 or 45 tons—rails dry, and moderate side wind.

The *thirteenth* and last experiment was with the "Milo," and a train of three passenger-carriages and a luggage-van. Weight, about 34 or 35 tons. A brisk side wide prevailed.

In this experiment the steam was shut off at the 172¾ mile-post, which is in the White Ball Tunnel.

*Tables of Experiments.*

| Gradient. | Mile Posts. | Velocity in Miles per Hour. 1st Experimnt. | 2nd Experimnt | 3rd Experimnt | 4th Experimnt | 5th Experimnt | 6th Experimnt | 7th Experimnt | 8th Experimnt | 9th Experimnt |
|---|---|---|---|---|---|---|---|---|---|---|
| 1/100 | 84½ | 58·1 | 50 | 52·2 | 54·5 | 51·4 | 56·3 | 58·1 | 56·3 | 56·3 |
| | 85 | 60 | 50 | 53·7 | 54·5 | 51·4 | 58·1 | 58·1 | 56·3 | 54·5 |
| | 85¼ | 58·1 | 50 | 50·7 | 51·4 | 52·9 | 57·1 | 57·1 | 53·7 | 54·5 |
| | 85½ | 59 | 52·2 | 54·5 | 52·9 | 52·2 | 56·3 | 59 | 55·4 | 52·9 |
| | 85¾ | 54·5 | 50·7 | 52·2 | 51·4 | 53·7 | 52·9 | 57·1 | 52·9 | 50·7 |
| | 86 | 54·5 | 50·7 | 52·2 | 51·4 | 52·9 | 53·7 | 57·1 | 53·7 | 50·7 |
| | 86¼ | 54·5 | 50·7 | 52·2 | 51·4 | 52·9 | 59·9 | 57·1 | 52·9 | 50·7 |
| 1/660 | 86½ | 53·7 | 50·7 | 51·4 | 51·4 | 52·2 | 54·5 | 56·3 | 53·7 | 50·7 |
| | 86¾ | 52·9 | 50 | 50 | 51·4 | 52·2 | 52·9 | 56·3 | 53·7 | 50 |

| Gradient. | Mile Posts. | Velocity in Miles per Hour. 11th Experiment | 13th Experiment | Gradient. | Mile Posts. | Velocity in Miles per Hour. 10th Experiment | 12th Experiment |
|---|---|---|---|---|---|---|---|
| 1/82 | 172½ | 43·9 | 55·4 | 1/120 | 174¼ | 36·3 | 37·5 |
| | 172¼ | 44·5 | 55·4 | | 174½ | 38·3 | 37·9 |
| | 172 | 45 | 56·3 | | 174¾ | 38·3 | 37·9 |
| 1/90 | 171¾ | 46·2 | 55·4 | | 175 | 39·6 | 38·3 |
| | 171½ | 47·4 | 54·5 | | 175¼ | 40 | 38·3 |
| | 171¼ | 48·6 | 56·3 | | 175½ | 40·9 | 39·1 |
| | 171 | 49·3 | 56·3 | | 175¾ | 41·4 | 38·7 |
| | 170¾ | 50 | 56·3 | | 176 | 41·9 | 39·1 |
| | | | | | 176¼ | 42·4 | 40 |

## REVIEWS.

*Account of the Skerryvore Lighthouse, with notes on the Illumination of Lighthouses.* By Alan Stevenson, LL.B., F.R.S.E., M.I.C.E., Engineer to the Northern Lighthouse Board. Edinburgh: Adam and Charles Black, 1848.

[SECOND NOTICE.]

What Mr. Stevenson calls "Notes on the Illumination of Lighthouses," may more rightly be called another work, and one not less important nor valuable than the account of the Skerryvore Lighthouse. Indeed, he calls the former Part II. He begins it by a short history of lighthouses, in which he shows a great deal of learning; and as by the former part every one will see that he is a hard-working man, so by this they will see that a man may be able to understand Homer in Greek, and yet be a good engineer.

We think both of those are wrong, those who wish to make the engineer a man of book-learning only, and those who want to make him a boor under the name of a working-man. Brunel, Robert Stephenson, Locke, the Rennies, Walker, and many more, have shown that to be a great engineer, and to make great works, there is no harm in a man being well-taught. We would always put the two together if we could,—we would have the man of learning and the working-man.

Mr. Stevenson's way of commenting on the classics is rather a new one,—rather unlike the Byzantine school, Scaliger, and the Revival critics, or the great High Dutch lights of this day. Some of these who went before Mr. Stevenson have put forth the bold thought, that the Cyclops were the keepers of lighthouses; some bolder still, that by the Cyclops was shadowed forth the lighthouse itself. Mr. Stevenson's answer is, that in the ninth book of the Odyssey, and at the 146th line, Homer tells us that in the darkness of the night, the fleet of Ulysses went ashore on the Cyclopean island. Mr. Stevenson looks at it with a workman's eye, and he says if there had been a lighthouse, the ships would not have struck in the dark. The words he brings forward show that it was pitch dark, and give no hint of a lighthouse; and therefore we think Mr. Stevenson right, in the teeth of the commentators. He has not, however, taken the trouble to set his Greek into English, so that his working readers may understand it.

What Mr. Stevenson says of the lighthouses of our days is the more worthy of being read, as he has seen many of them himself, and looked at them with the eye of a master.

Speaking upon lighting, Mr. Stevenson says, that down to a very late time, the only way was to burn wood or coal in chafing dishes on the tops of high towers or hills. Many now living know that the Isle of May light was of that kind, before it came under the care of the Board of Northern Lights in 1786. For forty years after the time of Smeaton, the fine tower of the Eddystone was lighted only with tallow candles. These lights were therefore very weak, and there were no means of knowing one light from another, so that the seaman might shape his way. Even now, it too often happens that seamen mistake lights, and by going inside, instead of outside or otherwise, they go aground and are wrecked. The old lighthouses were of little more good than to give warning that land was near; so that ships might, if they could, lie by or put out to sea until daylight.

Mr Stevenson now speaks of flame. He says:—

"Solid substances which remain so throughout their combustion, are only luminous at their own surface, and exhibit phenomena, such as the dull red heat of iron, or of most kinds of pit-coal, and are therefore more suited for the purpose of producing heat than light. But by using substances which are formed into inflammable vapours, at a temperature below that which is required for the ignition of the substances themselves, gas is obtained and *flame* is produced. Much light is thus evolved at a comparatively low temperature. The gas necessarily rises *above* the combustible substance from which it is evolved, owing to its being formed at a temperature considerably higher than that of the surrounding air, than which it is necessarily rarer. Of this description are the flames obtained by the burning of the various oils, which are generally employed in the illumination of lighthouses. In the combustion of oil, wicks of some fibrous substance, such as cotton, are used, into which the oil ascends by capillary action, and being supplied in very thin films, is easily volatilized into vapour or gas by the heat of the burning wick. The gas of pit-coal has been occasionally used in lighthouses; it is conveyed in tubes to the burners, in the same manner as when employed for domestic purposes. There are certain advantages, more especially in dioptric lights, where there is only one large central flame, which would render the use of gas desirable. The form of the flame, which is an object of considerable importance, would thus be rendered less variable, and could be more easily regulated, and the inconvenience of the clock-work of the lamp would be wholly avoided. But it is obvious, that gas is by no means suitable for the majority of lighthouses, their distant situation and generally difficult access rendering the transport of large quantities of coal expensive and uncertain; whilst in many of them there is no means of erecting the apparatus necessary for manufacturing gas. There are other considerations which must induce us to pause before adopting gas as the fuel of lighthouses; for, however much the risk of accident may be diminished in the present day, it still forms a question, which ought not to be hastily decided, how far we should be justified in running even the most remote risk of explosion in establishments such as lighthouses, whose sudden failure might involve consequences of the most fatal description, and whose situation is often such, that their re-establishment must be a work of great expense and time. Gas is, besides, far from being suitable in catoptric lights, to which, in many cases (especially when the frame is moveable, as in revolving lights), it could not be easily applied. The oil most generally employed in the lighthouses of England is the sperm oil of commerce, which is obtained from the South Sea whale (*Physeter macrocephalus*). In France, the colza oil, which is expressed from the seed of a species of wild cabbage (*Brassica oleracea colza*), and the olive oil are chiefly used; and a species of the former has lately been successfully introduced into the lighthouses of Great Britain."

Sperm oil is that which has been hitherto most burned; but colza oil will, it is thought, be found much better, and that a saving of one-half can be made. It was Mr. Joseph Hume, when chairman of a committee of the House of Commons on Lighthouses, who showed that colza oil was cheaper. Since then, Mr. Stevenson has tried it, and has told the Northern Lighthouse Board that it will give a saving of £3,266 yearly; but since that, colza oil is worth more, and Mr. Stevenson is not so strong in his feeling about it.

Of the Drummond and Voltaic lights, the writer says:—

"The application of the *Drummond* and *Voltaic lights* to lighthouse purposes is, owing to their prodigious intensity, a very desirable consummation; but it is surrounded by so many practical difficulties that, in the present state of our knowledge, it may safely be pronounced unattainable. The uncertainty which attends the exhibition of both these lights, is of itself a sufficient reason for coming to this conclusion. But other reasons unhappily are not wanting. The smallness of the flame renders them wholly inapplicable to dioptric instruments which require a great body of flame in order to produce a degree of divergence sufficient to render the duration of the flash in revolving lights long enough to answer the purpose of the mariner. M. Fresnel made some experiments on the application of the Drummond light to dioptric instruments, which completely demonstrate their unfitness for this combination. He found that the light obtained by placing it in the focus of a great annular lens was much more intense than that produced by the great lamp and lens; but the divergence did not exceed 30′; so that, in a revolution like that of the Corduan light, the flashes would last only 1½ second, and would not, therefore, be seen in such a manner as to suit the practical purposes of a revolving light. The great cylindric refractor used in fixed lights of the first order, was also tried with the Drummond light in its focus; but it gave coloured spectra at the top and bottom, and only a small bar of white light was transmitted from the centre of the instrument. The same deficiency of divergence completely unfits the combination of the Drummond light with the reflector for the purposes of a fixed light, and even if this cause did not operate against its application in revolving lights on the catoptric plan, the supply of the gases, which is attended with almost insurmountable difficulties, would, in any case, render the maintenance of the light precarious and uncertain in the last degree.

The Drummond light is produced by the ignition or combustion of a ball of lime (⅜ inch diameter) in the united flames of hydrogen and oxygen gases, and is equal to about 264 flames of an ordinary Argand lamp with the best spermaceti oil. It derives its name from the late Lieut. Drummond, R. E., who first applied it in the focus of a paraboloïd for geodetical purposes, and afterwards proposed it for lighthouses. (See his account of the light in the Phil. Trans. for 1826, p. 324, and for 1830, p. 383.) The Voltaic light is obtained by passing a stream of Voltaic electricity from a powerful battery between two *charcoal points*, the distance between which requires great nicety of adjustment, and is the chief circumstance which influence the stability and the permanency of the light. The Voltaic light greatly exceeds the Drummond light in intensity, as ascertained by actual comparison of their effects; but the ratio of their power has not beep accurately determined. It was first exhibited in the focus of a reflector by Mr. James Gardner, formerly engaged in the Ordnance Survey of Great Britain."

After speaking of what Argand did, and of the burner he made, which was such a great step, Mr. Stevenson comes to the reflector:

"The name of the inventor of paraboloïdal mirrors and the date of their first application to lighthouses, have not been accurately ascertained. The earliest notice which I have been able to find, is that by Mr. William Hutchinson, the pious and intelligent author of a quarto volume on 'Practical Seamanship' (published at Liverpool in 1791), who notices (at p. 93) the erection of the four lights at Bidstone and Hoylake, in the year 1763, and describes large parabolic moulds, fashioned of wood and lined with mirror-glass, and smaller ones of polished tin-plate, as in use in those lighthouses. Mr. Hutchinson seems to have understood the nature, properties, and defects of the instruments which he describes, and has shown a good acquaintance with many of the most important circumstances to be attended to in the illumination of lighthouses. Many claims to inventions rest on more slender grounds than might be found in Mr. Hutchinson's book for concluding him to have first invented the paraboloïdal mirror and applied it to use in a lighthouse; but, in the absence of any statement as to the date when the mirrors were really adopted, the merit of the improvement must, in justice, be awarded to others.

M. Teulere, a member of the Royal Corps of Engineers of Bridges and Roads in France, is, by some, considered the first who hinted at the advantages of paraboloïdal reflectors; and he is said, in a memoir dated the 26th June 1783, to have proposed their combination with Argand lamps, ranged on a revolving frame, for the Corduan lighthouse. Whatever foundation there may be for the claim of M. Teulere, certain it is that this plan was actually carried into effect at Corduan, under the directions of the Chevalier Borda; and to him is generally awarded the merit of having conceived the idea of applying paraboloïdal mirrors to lighthouses. These were most important steps in the improvement of lighthouses, as not only the power of

the lights was thus greatly increased, but the introduction of a revolving frame proved a valuable source of differences in the appearance of lights, and, in this way, has since been the means of greatly extending their utility. The exact date of the change on the light of the Corduan is not known; but as it was made by Lenoir, the same young artist to whom Borda, about the year 1780, entrusted the construction of his reflecting circle, it has been conjectured by some that the improvement of the light was made about the same time. The reflectors were formed of sheet-copper, plated with silver, and had a double ordinate of 31 French inches. It was not long before these improvements were adopted in England, by the Trinity House of London, who sent a deputation to France to inquire into their nature. In Scotland, one of the first acts of the Northern Lights Board in 1786, was to substitute reflectors in the room of the coal-light then in use at the Isle of May in the Frith of Forth, which, along with the light on the Cambrae Isle in the Frith of Clyde, had, till that period, been the only beacons on the Scotch coast. The first reflectors employed in Scotland were formed of *facets* of mirror-glass, placed in hollow paraboloïdal moulds of plaster, according to the designs of the late Mr. Thomas Smith, the Engineer of the Board, who (as appears from the article *Reflector*, in the Supplement to the third edition of the 'Enclyclopædia Britannica') was not aware of what had been done in France, and had himself conceived the idea of this combination. The same system was also adopted in Ireland; and in time, variously modified, it became general wherever lighthouses are known."

The reflectors used in the best lighthouses are made, says the writer,

"Of sheet-copper plated in the proportion of six ounces of silver to sixteen ounces of copper. They are moulded to the paraboloïdal form, by a delicate and laborious process of beating with mallets and hammers of various forms and materials, and are frequently tested during the operation by the application of a mould carefully formed. After being brought to the curve, they are stiffened round the edge by means of a strong bizzle, and a strap of brass which is attached to it for the purpose of preventing an accidental alteration of the figure of the reflector. Polishing powders are then applied, and the instrument receives its last finish."

"The flame generally used in reflectors, is from an Argand fountain-lamp, whose wick is an inch in diameter. Much care is bestowed upon the manufacture of the lamps for the Northern lighthouses, which sometimes have their burners tipped with silver to prevent wasting by the great heat which is evolved. The burners are also fitted with a sliding apparatus, accurately formed, by which they may be removed from the interior of the mirror at the time of cleaning them, and returned exactly to the same place, and locked by means of a key. This arrangement, as shown in figs. 1 and 2,

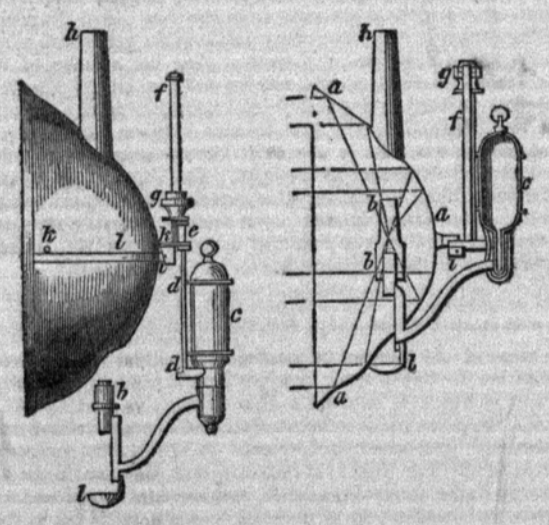

Fig. 2. Fig. 1.

is very important, as it insures the burner always being in the focus, and does not require that the reflector be lifted out of its place every time it is cleaned; so that, when once carefully set and screwed down to the frame, it is never altered."

It will please our readers very much to find in Mr. Stevenson's book, the many clever tools which are used, and care which is taken to make the lamps and lights as good as may be. He has written a good deal about feeding the lamps with oil, and indeed everywhere he has shown that he is master of his work, even in the smallest things. It was said of the Duke of Wellington, that even to the horses' shoes he knew everything in his army, and that he thought nothing beneath him which had to do with the welfare of his men: and so should it be with the engineer; and this is the way in which he can truly become a working-man. Mr. Stevenson may not perhaps have put on a fustian coat, nor spent his time in filing, rasping, and fitting; but an engineer may be a working-man without that.

Lights are found by seamen so useful, that they are always calling out for more; but when put up, it becomes very troublesome to know one from another. A light ought to make known to the benighted mariner the land he has made, as the sight of a hill or tower would have shown him in the day; therefore, it becomes needful that each should be readily known, so as not to be mistaken.

"Catoptric lights are susceptible of nine separate distinctions, which are called *fixed, revolving white, revolving red and white, revolving red with two whites, revolving white with two reds, flashing, intermittent, double fixed lights*, and *double revolving white lights*. The first exhibits a steady and uniform appearance, which is not subject to any change; and the reflectors used for it (as already noticed) are of smaller dimensions than those employed in revolving lights. This is necessary in order to permit them to be ranged round the circular frame, with their axes inclined at such an angle, as shall enable them to illuminate every point of the horizon. The revolving light is produced by the revolution of a frame with three or four sides, having reflectors of a larger size grouped on each side, with their axes parallel; and as the revolution exhibits once in two minutes, or once in a minute, as may be required, a light gradually increasing to *full strength*, and in the same gradual manner decreasing to total darkness, its appearance is extremely well marked. The succession of *red* and *white* lights is caused by the revolution of a frame whose different sides present red and white lights; and these, as already mentioned, afford three separate distinctions, namely, alternate red and white; the succession of two white lights after one red, and the succession of two red lights after one white light. The *flashing* light is produced in the same manner as the *revolving* light; but owing to a different construction of the frame, the reflectors on each of eight sides are arranged with their rims or faces in one vertical plane, and their axes in a line inclined to the perpendicular, a disposition of the mirrors which, together with the greater quickness of the revolution, which shows a flash once in five seconds of time, produces a very striking effect, totally different from that of a revolving light, and presenting the appearance of the flash alternately rising and sinking. The brightest and darkest periods being but momentary, this light is farther characterised by a rapid succession of bright flashes, from which it gets its name. The *intermittent* light is distinguished by bursting suddenly into view and continuing steady for a short time, after which it is suddenly eclipsed for half a minute. Its striking appearance is produced by the perpendicular motion of circular shades in front of the reflectors, by which the light is alternately hid and displayed. This distinction, as well as that called the *flashing light*, is peculiar to the Scotch coast, having been first introduced by the late Engineer of the Northern Lights Board. The double lights (which are seldom used except where there is a necessity for a *leading* line, as a guide for taking some channel or avoiding some danger) are generally exhibited from two towers, one of which is higher than the other. At the Calf of Man, a striking variety has been introduced into the character of leading lights, by substituting, for two *fixed* lights, two lights which revolve in the same periods, and exhibit their flashes at the same instant; and these lights are, of course, susceptible of the other variety enumerated above, that of two revolving red and white lights, or flashing lights, coming into view at equal intervals of time. The utility of all these distinctions is to be valued with reference to their property of at once striking the eye of an observer, and being instantaneously obvious to strangers."

Although colour is needful, it is in itself a very great evil, for the coloured screens stop much of the light. Several colours have been tried, but red, blue, and green have alone been found useful; and the two latter only at such short lengths, that they are altogether unfit for sea-lights. Even the red lights take up from four-sevenths to five-sixths of the whole light, which is a very great loss; and the deeper the red, the greater the loss of light,—while the less red there is, the less can it be seen by the seaman. Red lights ought, therefore, to be used as little as may be. In Scotland, instead of a red screen or disc, a chimney of red glass is used.

We now come to the use of lenses, upon which the writer says:—

"One of the earliest notices of the application of lenses to lighthouses is that recorded by Smeaton in his 'Narrative of the Eddystone Lighthouse,' where he mentions a London optician, who, in 1759, proposed grinding the glass of the lantern to a radius of seven feet six inches; but the description is too vague to admit of even a conjecture regarding the proposed arrangement of the apparatus. About the middle of the last century, however, lenses were actually tried in several lighthouses in the south of England, and in particular at the South Foreland in the year 1752; but their imperfect figure and the quantity of light absorbed by the glass, which was of impure quality and of considerable thickness, rendered their effect so much inferior to that of the parabolic reflectors then in use, that after trying some strange combinations of lenses and reflectors, the former were finally abandoned. Lenses were also tried at the lights of Portland, Hill of Howth, and Waterford, by Mr. Thomas Rogers, a glass manufacturer in London; who possessed, it is said, the art of blowing mirrors of glass, 'and by a new method silvered over the convex side without quicksilver.'

"The merit of having first suggested the building of lenses in separate

pieces, seems to be due to Condorcet, who in his *Eloge de Buffon*, published so far back as 1773, enumerates the advantages to be derived from this method. Sir David Brewster also described this mode of building lenses in 1811, in the *Edinburgh Encyclopædia;* and in 1822, the late eminent Fresnel, unacquainted with the suggestions of Condorcet or the description by Sir David Brewster, explained, with many ingenious and interesting details, the same mode of constructing those instruments. To Fresnel belongs the additional merit of having first followed up his invention, by the construction of a lens and, in conjunction with MM. Arago and Mathieu, of placing a powerful lamp in its focus, and indeed of finally applying it to the practical purposes of a lighthouse."

To show Fresnel's system fully would take more room than we can give, and many wood-cuts, and we are sorry that we must leave it alone, and send our readers to Mr. Stevenson's book, where everything is given in full,—Fresnel's brother having put his papers in Mr. Stevenson's hands.

One of Mr. Stevenson's own works was with the Isle of May light.

"Having been directed by the commissioners of the Northern lighthouses to convert the fixed catoptric light of the Isle of May, into a dioptric light of the first order, I proposed that an attempt should be made to form a true cylindric, instead of a polygonal belt for the refracting part of the apparatus; and this task was successfully completed by Messrs. Cookson of Newcastle in the year 1836. The disadvantage of the polygon lies in the excess of the radius of the circumscribing circle over that of the inscribed circle, which occasions an unequal distribution of light between its angles and the centre of each of its sides; and this fault can only be fully remedied by constructing a cylindric belt whose generating line is the middle mixtilinear section of an *annular* lens, revolving about a vertical axis passing through its principal focus. This is, in fact, the only form which can possibly produce an equal diffusion of the incident light over every part of the horizon.

"I at first imagined that the whole hoop of refractors might be built between two metallic rings, connecting them to each other solely by the means employed in cementing the pieces of the annular lenses; but a little consideration convinced me that this construction would make it necessary to build the zone at the lighthouse itself, and would thus greatly increase the risk of fracture. I was therefore reluctantly induced to divide the whole cylinder into ten arcs, each of which being set in a metallic frame, might be capable of being moved separately. The chance of any error in the figure of the instrument has thus a probability of being confined within narrower limits; whilst the rectification of any defective part becomes at the same time more easy. One other variation from the mode of construction at first contemplated for the Isle of May refractors, was forced upon me by the repeated failures which occurred in attempting to form the middle zone in one piece; and it was at length found necessary to divide this belt by a line passing through the horizontal plane of the focus. Such a division of the central zone, however, was not attended with any appreciable loss of light, as the entire coincidence of the junction of the two pieces with the horizontal plane of the focus, confines the interception of the light to the fine joint at which they are cemented. With the exception of those trifling changes, the idea at first entertained of the construction of the instrument was fully realised at the manufactory of Messrs. Cookson."

Speaking of Fresnel's lamp, used in the French lighthouses, Mr. Stevenson writes:—

"The only risk in using this lamp arises from the liability to occasional derangements of its leathern valves that force the oil by means of clockwork; and several of the lights on the French coast, and more especially the Corduan, have been extinguished by the failure of the lamp for a few minutes, an accident which has never happened, and scarcely can occur with the fountain lamps which illuminate the reflectors. To prevent the occurrence of such accidents, and to render their consequences less serious, various precautions have been resorted to. Amongst others, an alarum is attached to the lamp, consisting of a small cup pierced in the bottom, which receives part of the overflowing oil from the wicks, and is capable, when full, of balancing a weight placed at the opposite end of a lever. The moment the machinery stops, the cup ceases to receive the supply of oil, and, the remainder running out at the bottom, the equilibrium of the lever is destroyed, so that it falls and disengages a spring which rings a bell sufficiently loud to waken the keeper should he chance to be asleep. It may justly be questioned whether this alarum would not prove a temptation to the keepers to relax in their watchfulness and fall asleep; and I have, in all the lamps of the dioptric lights on the Scotch coast, adopted the converse mode of causing the bell to cease when the clockwork stops. There is another precaution of more importance, which consists of having always at hand in the light-room a spare lamp, trimmed and adjusted to the height for the focus, which may be substituted for the other in case of accident."

In the French lights, "these distinctions depend upon the periods of revolution, rather than upon the *characteristic appearance* of the light; and therefore seem less calculated to strike the eye of a seaman, than those employed on the coasts of Great Britain and Ireland. In conformity with this system, and in consideration of the great loss of light which results from the application of coloured media, all distinctions based upon colour have been discarded in French lights.

"The distinctions are, in fact, only *four* in number, viz.: fixed; fixed varied by flashes; revolving, with flashes once a minute; and revolving with flashes every half minute. To those might be added, revolving, with bright periods once in two minutes, and perhaps *flashing* once in *five seconds* (as introduced by me at the Little Ross, but I cannot say with such complete success as would induce me to recommend its general adoption). My own experience would also lead me to reject the distinction called 'fixed, varied by flashes,' which I do not consider as possessing a marked or efficient character."

For putting lights on a shore, Mr. Stevenson lays down a few laws for the engineer, which will be found very useful for those of our readers who may have to build lighthouses in our settlements abroad:—

"1. The most prominent points of a line of coast, or those first made on *over-sea* voyages, should be first lighted; and the most powerful lights should be adapted to them, so that they may be discovered by the mariner as long as possible before his reaching land.

2. So far as is consistent with a due attention to distinction, revolving lights of some description, which are necessarily more powerful than fixed lights, should be employed at the outposts on a line of coast.

3. Lights of precisely identical character and appearance should not, if possible, occur within a less distance than 100 miles of each other on the same line of coast, which is made by over-sea vessels.

4. In all cases, the distinction of colour should never be adopted except from absolute necessity.

5. Fixed lights and others of less power, may be more readily adopted in narrow seas, because the *range* of the lights in such situations is generally less than that of open sea-lights.

6. In narrow seas also, the distance between lights of the same appearance may often be safely reduced within much lower limits than is desirable for the greater sea-light; and there are many instances in which the distance separating lights of the same character need not exceed 50 miles, and there are peculiar cases in which even a much less separation between similar lights may be sufficient.

7. Lights intended to guard vessels from reefs, shoals, or other dangers, should in every case be placed, where practicable, to the seaward of the danger itself, as it is desirable that seamen be enabled to make the lights with confidence.

8. Views of economy in the first cost of a lighthouse should never be permitted to interfere with placing it in the best possible position; and, when funds are deficient, it will generally be found that the wisest course is to delay the work until a sum shall have been obtained sufficient for the erection of the lighthouse on the best site.

9. The elevation of the lantern above the sea should not, if possible, for sea-lights, exceed 200 feet; and about 150 feet is sufficient, under almost any circumstances, to give the range which is required. Lights placed on high headlands are subject frequently to be wrapped in fog, and are often thereby rendered useless, at times when lights on a lower level might be perfectly efficient. But this rule must not, and indeed cannot, be strictly followed, especially on the British coast, where there are so many projecting cliffs, which, while they subject the lights placed on them to occasional obstruction by fog, would also entirely and permanently hide from view lights placed on the lower land adjoining them. In such cases, all that can be done is carefully to weigh all the circumstances of the locality, and choose that site for the lighthouse which seems to afford the greatest balance of advantage to navigation. As might be expected, in questions of this kind, the opinions of the most experienced persons are often very conflicting, according to the value which is set on the various elements which enter into the inquiry.

10. The best position for a sea-light ought rarely to be neglected for the sake of some neighbouring port, however important or influential; and the interests of navigation, as well as the true welfare of the port itself, will generally be much better served by placing the sea-light *where it ought to be*, and adding, on a smaller scale, such subsidiary lights as the channel leading to the entrance of the port may require.

11. It may be held as a general maxim, that the fewer lights that can be employed in the illumination of a coast the better, not only on the score of economy, but also of real efficiency. Every light needlessly erected may, in certain circumstances, become a source of confusion to the mariner, and, in the event of another light being required in the neighbourhood, it becomes a *deduction* from the means of distinguishing it from the lights which existed previous to its establishment. By the needless erection of a new lighthouse, therefore, we not only expend public treasure, but waste the means of distinction among the neighbouring lights.

12. Distinctions of lights, founded upon the minute estimation of intervals of time between flashes, and especially on the measurement of the duration of light and dark periods, are less satisfactory to the great majority of coasting seamen, and are more liable to derangement by atmospheric changes, than those distinctions which are founded on what may more properly be called the *characteristic appearance* of the lights, in which the times for the recurrence of certain appearances differ so widely from each other as not to require for their detection any very minute observation in a stormy night. Thus, for example, flashing lights of five seconds interval, and revolving lights of half a minute, one minute, and two minutes, are much more characteristic than those which are distinguished from each other by intervals varying according to a slower series of 5″, 10″, 20″, 40″, &c.

13. Harbour and local lights, which have a circumscribed range, should generally be fixed instead of revolving; and may often, for the same

reason, be safely distinguished by coloured media. In many cases also, where the purpose of guiding into a narrow channel is to be gained, the leading lights which are used, should, at the same time, be so arranged as to serve for a distinction from any neighbouring lights.

14. Floating lights, which are very expensive and more or less uncertain from their liability to drift from their mooring, as well as defective in power, should never be employed to indicate a turning point in a navigation in any situation where the conjunction of lights on the shore can be applied at any reasonable expense."

The building of the lantern is a work of great care, and in which our writer has very cleverly made an improvement:—

"A considerable practical defect in all the lighthouse lanterns which I have ever seen, with the exception of those recently constructed for the Scotch lighthouses, consists in the vertical direction of the astragals, which, of course, tend to intercept the whole or a great part of the light in the azimuth which they subtend. The consideration of the improvement which I had effected in giving a diagonal direction to the joints of the fixed refractors, first led me to adopt a diagonal arrangement of the framework which carries the cupola of zones, and afterwards for the astragals of the lantern. Not only is this *direction* of the astragals more advantageous for equalising the effect of the light; but the greater stiffness and strength which this arrangement gives to the frame-work of the lantern make it safe to use more slender bars, and thus also absolutely *less* light is intercepted. The panes of glass at the same time become triangular, and are necessarily stronger than rectangular panes of equal surface. This form of lantern is extremely light and elegant. To avoid the necessity of painting, which, in situations so exposed as those which lighthouses generally occupy, is attended with many inconveniences and no small risk, the framework of the lantern is now formed of gun-metal and the dome is of copper; so that a first-order lantern of 12 feet diameter and 10 feet height of glass costs, when glazed, about £1260. In order to give the lightkeepers free access to cleanse and wash the upper panes of the lantern (an operation which in snowy weather must sometimes be frequently repeated during the night), a narrow gangway, on which they may safely stand, is placed on the level of the top of the lower panes, and at the top of the second panes, rings are provided of which the lightkeepers may lay hold for security in stormy weather. A light trap-ladder is also attached to the outside of the lantern, by means of which there is an easy access to the ventilator on the dome.

Great care is bestowed on the glazing of the lantern, in order that it may be quite impervious to water, even during the heaviest gales. When iron is used for the frames, they are carefully and frequently painted; but gun-metal, as just noticed, is now generally used in the Scotch lighthouses. There is great risk of the glass plates being broken by the shaking of the lantern during high winds; and as much as possible to prevent this, various precautions are adopted. The arris of each plate is always carefully rounded by grinding; and grooves about half an inch wide, capable of holding a good thickness of putty, are provided in the astragals for receiving the glass, which is a quarter of an inch thick. Small pieces of lead or wood are inserted between the frames and the plates of glass against which they may press, and by which they are completely separated from the more unyielding material of which the lantern-frames are composed. Panes glazed in frames padded with cushions, and capable of being temporarily fixed in a few minutes, in the room of a broken plate, are kept ready for use in the store-room. Those framed plates are called *storm-panes*, and have been found very useful on several occasions, when the glass has been shattered by large sea-birds coming against it in a stormy night, or by small stones violently driven against the lantern by the force of the wind.

The ventilation of the lanterns forms a most important element in the preservation of a good and efficient light. An ill-ventilated lantern has its sides continually covered with water of condensation, which is produced by the contact of the ascending current of heated air; and the glass thus obstructs the passage of the rays, and diminishes the power of the light."

We must now shut up Mr. Stevenson's book, though we could very well take more from it, for it is full of new and useful matter. We cannot, however, do so without giving our thanks to the Board of Northern Lights for publishing this book, as they before did the elder Stevenson's book on the Bell-rock lighthouse. In our last number we called strongly on the engineers to write books on their works; but, perhaps, we should have done better if we had called on the railway and other undertakings to find the money for it, as the Board of Northern Lights have done. There is something wrong now, and we cannot help thinking that the engineers are those most to blame. If Mr. Robert Stephenson would take under his care a book on the London and Birmingham Railway, we do believe that the shareholders would not grudge the money, as each of them could have a book. They have not grudged money for Wolverton, and we do not think they would for this, if it were fairly put before them by their engineer. The shareholders would never miss the money, while they would do a great deal of good. If the engineers do not stir, we hope the shareholders will; and that we shall have books on our great railway works, which may keep up their name and the honour of England.

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*Mathematics for Practical Men, being a common-place book of Pure and Mixed Mathematics, designed chiefly for the use of Civil Engineers, Architects, and Surveyors; by* Olinthus Gregory, LL.D., F.R.A.S. Third Edition, Revised and Enlarged. By Henry Law, civil engineer. London: Weale, 1848. 8vo. pp. 510.

This is a new edition of a very well known book. An editor who undertakes the revision of the scientific labours of another writer, undertakes an onerous and difficult task. If he alter and interpolate freely, he may be charged with disrespect towards his author: if, on the other hand, he adhere too faithfully to the text, he becomes responsible for the original errors, as well as for all which he himself may happen to commit.

Dr. Olinthus Gregory, of the Woolwich Military Academy, published the first edition of his "Mechanics for Practical Men," in 1825; and eight years after, a subsequent edition, in which he says, "I have corrected a few errors which had escaped my notice in the former impression." The work commences with an elementary treatise on arithmetic and algebra, and the remainder is devoted to geometry and the mechanical sciences. This part of the work is, in his own phraseology, "synoptical." "The definitions and principles are exhibited in an orderly series, but investigations and demonstrations are only sparingly introduced." So much the greater, then, the importance of accuracy. Where results only are given, the reader must trust entirely to the authority of the writer: the process of investigation being omitted, there are no possible means of ascertaining the accuracy of the conclusions. They must be taken on trust. Like bank-notes, they may or may not represent sterling value; but in the absence of direct information, their circulation depends entirely on the credit of the issuer.

Engineers at the present day are pretty well agreed, that the accuracy of formulæ is something more than a matter of mere speculative interest—that, on the contrary, it has a real and tangible importance, quite apart from theoretical considerations. It was at one time thought that mathematical investigations of questions of engineering were matters of mere curiosity—learned pastimes. Now it is found, that if a bridge be constructed according to insufficient formulæ, it not only *ought* theoretically to fall down, but practically *will* do so. And if the duty of a steam-engine for a given quantity of fuel be inaccurately computed, not only are the laws of science infringed—but the pocket of the owner of the engine suffers also. In this way, scientific accuracy comes to have a practical importance, a real money value: and those who prided themselves that they were "practical men," and thanked heaven that they never troubled themselves about scientific theories,—which were all very well for college-students, and people who have nothing else to do,—discern faintly that their self-congratulation is premature.

These considerations render us very anxious that the theoretical science should not suffer discredit, nor practical engineering injury by misplaced confidence: and with this object in view, we proceed to the more particular examination of the work under review,—premising that, as far as we have compared it with the preceding edition, most of the errors appear to be Dr. Gregory's originally, and Mr. Law's by imputation only; and it is nothing but fair to suppose that the latter was actuated by a feeling of deference towards his author.

We pass over the treatises on arithmetic and algebra without examination; being altogether elementary, they may be presumed to be correct. Our criticism commences with the definitions of Curves.

"A *cycloid* or *trochoid* is an elegant mechanical curve, first noticed by Descartes, and an account of which was published by Mersenne in 1615. It is in fact the curve described by a nail in the rim of a carriage-wheel while it makes one revolution on a flat horizontal plane."

Cycloids "*or*" trochoids are used as synonymous words! They are names of curves essentially different: for the former, the tracing point is on the circumference of the generating circle—for the latter, the tracing point is within or beyond that circumference.

"If the generating circle, instead of rolling along a straight line, is made to roll upon the circumference of another circle, the curve described by any point in its circumference is called an *epicycloid*."

It is *not* called an epicycloid except when the generating circle is equal to the fixed circle, and rolls on the exterior of it. In the other cases, the curve generated is either a Hypotrochoid, Epitrochoid, or Hypocycloid. In the figure illustrating the definition of an epicycloid, this mistake is aggravated, by representing the rolling curve as much larger than the fixed curve.

It is of the very essence of mathematical definitions that they should be precise and comprehensive; and in no part of mathematics is this exactness of definition more necessary than in me-

chanics. What will our mathematical readers say of such a definition as the following?

"When the forces that act upon a body, destroy or annihilate each other's operation, so that the body remains quiescent, they are said to be in *equilibrium*, and are then called *pressures*."

This is clumsy and incomplete, to say the least. It is assumed, that when two forces "annihilate each other's operations," the body is at rest,—the case of uniform motion is overlooked. Besides, the word *pressure* is restricted to statical forces, whereas it is properly applied to dynamical forces also.

"*Vis viva*, or living force, a term used by Leibnitz to denote the force or power of a body in motion; or the force which would be required to bring it to rest."

Leibnitz never did anything half so absurd as is here said of him. *Vis viva* is not a force (or *power*,—for Dr. Gregory previously states that the words force and power are synonymous). *Vis viva* is a mere technical phrase—signifying, simply, mass multiplied by the square of velocity—which Dr. Gregory and his editor are determined to distort into something very complicated and abstruse. So far from *vis viva* being a force, it is not even *measured* by force alone—another element being the distance through which the force acts. When a body is acted upon by only one uniform force, the *vis viva* generated is equal to *twice* the force multiplied by the distance described in the direction of the force.

In the second problem of the chapter on Statics, the calculation respecting the strain on tie-beams and struts is totally erroneous. It is not worth while to state the problem here, as we could not make it intelligible without the diagrams. To the reader who has the work before him, it will be sufficient to state that the error arises from considering the forces at one end of the strut and tie-beam, and neglecting the forces at the other end of each. The conclusion is manifestly erroneous, for when the tie-beam became indefinitely long, it would be vertical, and the tension equal to the weight suspended; the strain on the strut at the same time becoming zero.

"If the particles or bodies of any system be moving uniformly and rectilineally, with any velocities and direction, the centre of gravity is either at rest, or moves uniformly in a right line."

This is not true. Does the author mean to assert, that if two bodies be moving with different velocities in straight lines perpendicular to each other, the common centre of gravity moves in a straight line?

In discussing the pressure of earth against walls, *the line of rupture* and the *natural slope* are said to be synonymous—they are entirely different things; the line of rupture being that which defines what is technically termed the wedge of maximum pressure. In the next paragraph is discussed the pressure exerted against the wall by the prism resting on the natural slope; whereas, by the very definition of natural slope, that prism exerts no such pressure, the friction being of the exact amount necessary to sustain the weight.

The section on the stability of the arch discusses the conditions for a case of rupture which is mechanically and geometrically impossible—that where there are only two joints of rupture, equidistant from the crown, the loading symmetrical, and the piers incapable of sliding. In the last of the formulæ in this section, the right-hand side of the equation has double it proper value.

The preliminary part of the chapter on Dynamics has been re-written,—not however, as we think, with great success. The confusion of ideas respecting *vis viva* is really marvellous, considering how simple the real signification of the phrase is. Mr. Law says, first, "Mechanical effect is measured by the product of the mass or weight of the body into the space over which it has moved." Then he defines the *vis viva* of a moving body as "the whole mechanical effect which it will produce in being brought to a state of rest." This definition is by no means satisfactory. First, the mass OR weight are spoken of as convertible terms. Next, coupling the two definitions, the *vis viva* is said to "produce" the mass or weight multiplied by the distance. This is a strange expression: however, if we leave out the word "mass," and for "distance" read "twice the distance," the idea intended to be conveyed is tolerably correct, where the motion is vertical and the only force is that of uniform gravity. For bodies acted on by variable force, and for curvilinear motion, the definition is totally inapplicable.

In place of an enunciation of the three laws of motion, we have the following *experiments* as the foundation of dynamics.

"From carefully conducted and often-repeated experiments, the following results with regard to bodies in motion have been obtained:—

"I. If a body of a certain weight, and moving with a given velocity, meet another body of double that weight, and moving with half the velocity, the two bodies will destroy each other's motion, and *both* will be brought to a *state of rest*.

"II. A body of a certain weight and moving with a given velocity, being subject to a uniformly retarding force (*i. e.* a uniform force acting constantly in a contrary direction to the body's motion), will move over a certain space in being brought to rest, and will occupy a certain time in doing so; then another body of the same weight, but moving with *half* the velocity of the former, being subject to the same uniformly retarding force, will move over *one quarter* of the space moved over by the former, in being brought to a state of rest, and will occupy in doing so *half* the time. And another body of the same weight, but moving with *one-third* of the velocity of the first, will move over *one-ninth* of the space, and occupy *one-third* the time of the first, in being brought to a state of rest."

The second experiment would be analogous to that of trying whether all points in the circumference of a circle possess the property of equidistance from the centre! It is a matter of definition that they should do so. In the same way, the mere definition of uniformly retarding force leads to the inference here indicated as the result of numberless experiments. The conclusion depends on mere geometry, not on any law of mechanics. If a horse set off at a constantly diminishing speed—50 feet the first second, 49 feet the next, 48 feet the next, and so on—it requires no knowledge of mechanics, but a simple arithmetical computation, to ascertain how far he has gone, and the time which has elapsed, when his velocity is reduced to 20 feet a second. In the same way, if a body be acted upon by a uniformly retarding force—that is, one which diminishes the velocity at an assigned uniform rate—the law of motion is assigned *â priori*, and it requires no experiment to determine the distances corresponding to subsequent rates of velocity. The rule that the distance traversed before the body comes to rest is proportional to the square of the velocity destroyed, depends on purely geometrical computation.

In the section on Motion on Inclined Planes, we find the following:—

"Each particle of matter in a rolling body resists motion in proportion to the square of its distance from the axis of motion."

There is no such resistance, either in proportion to the square of the distance from the axis of motion, nor in any other proportion. It is incorrect to say that matter resists motion; it neither resists nor assists it, but is perfectly impassive and inert. The *force of inertia*, as M. Poisson observes, is an incorrect phrase, arising from inaccurate notions of the properties of matter—it, in fact, implies an idea that matter has some inherent property of altering its own motion.

In the section treating of Pendulums, it is asserted, that if a body suspended from a fixed point by a flexible string be made to vibrate, it will always rise the same vertical distance as it has descended. This is of course true when the motion is not disturbed; but it is added, that if the motion of the string be intercepted by a projecting peg, so as to shorten the radius of the arc in which the body moves, the same property holds. That this is not generally true is obvious, from the consideration that the peg may be so near the vibrating body, that the radius becomes too short to allow the body to regain its original height. Moreover, the string receives a jerk; and therefore, unless it be perfectly elastic, there is a loss of *vis viva*.

After a confused and inaccurate definition and table of values of the radius of gyration for several bodies, we have the following lucid explanation of the principles of rotation:—

"If the matter in any gyrating body were actually to be pla ed as if in the centre of gyration, it ought either to be disposed in the circumference of a circle whose radius is R, or at two points R, R′, diametrically opposite, and each at a distance R from the centre."

All that can be made out of this is, that if the body be in one place, it "ought to be" in another. The only inference from such a statement is a querulous determination on the part of the writer to be dissatisfied with the position of the body under all circumstances. The feeling is that of the wolf toward the lamb in the fable—a general disinclination that the body should have *any* position. Several preceding sentences gave rise to the suspicion that the author did not clearly understand the subject on which he was writing—the sentence just quoted converts suspicion into certainty.

The following are the definitions at the commencement of a chapter on Central Forces:—

"(1.) *Centripetal force* is a force which tends constantly to solicit or to impel a body towards a certain fixed point or centre. (2.) *Centrifugal force* is that by which it would recede from such a centre, were it not prevented by the centripetal force. (3.) These two forces are, jointly, called *central forces*."

Centrifugal force is not, as here stated, directed towards a fixed centre. It is normal to the path of motion; and, therefore, there is

only one particular case—that of circular motion—in which the above definition is satisfied. In elliptical and other kinds of motion it is violated at every instant. This consideration is of itself sufficient to show that the third definition is also incorrect. Central forces are always taken by mathematicians to be forces directed from or towards a *fixed* centre—which centrifugal force is not.

The laws of motion about centres of attration are applied to cases to which they have no relation. The following problem is an instance :—

"If a fly, 2 tons weight and 16 feet diameter, is sufficient to regulate an engine when it revolves in 4 seconds; what must be the weight of another fly of 12 feet diameter revolving in 2 seconds, so that it may have the same power upon the engine?"

It seems scarcely credible that the solution of this problem is derived from the law of motion of a free body in a circle about a central force—that "the forces are as the distances or radii of the circles directly, and the forces inversely." Could it be believed, that a student who had read mathematics for six months, would apply a law, which is wholly independent of the mass acted upon, to a problem in which the mass is the most essential particular? By such logic, the following relation between the weights of the two fly wheels is established :—

$$\frac{W\,D}{T^2} = \frac{w\,d}{t^2};$$

where W, $w$, are the weights; D, $d$, the diameters of the wheels; and T, $t$, the times occupied in revolution. Now, to show the absurdity of all this, we have only to express the times in terms of the linear velocities, V, and $v$, and the above equation becomes

$$\frac{W\,V^2}{D} = \frac{w\,v^2}{d};$$

which leads to the conclusion, that for two fly wheels of equal weight, that having the greatest velocity must also have the greatest diameter!—a conclusion to which our practical readers would probably demur.

It would take up too much space to explain all that appears objectionable in the work before us. Mr. Law certainly has the credit of rendering the new edition somewhat better than the preceding, by introducing De Pambour's investigations of the power of the steam-engine, and by several improvements of arrangement.

In the paper on the Strength of Materials, which is almost entirely re-written, Mr. Law gives some valuable views of the subject, which cause us to regret that he has not exercised keener criticism in other parts of the work. In estimating the tranverse strength of materials, an ingenious theory is proposed, for representing the total forces of extension and compression in any section of a girder by solids, of which lines proportional to those forces are the horizontal ordinates. Unfortunately, he overlooks the fact that the total forces of longitudinal compression and tension are equal and opposite. He assumes also that their moments are equal—which is incorrect. This error vitiates equation (I), page 373, and all that depends on it.

Our review must close here, not from want of subjects for further comment, but because of the space which they would occupy. We have done little more than point out, in the briefest possible manner, a few errors here and there; and have avoided general observations, lest our criticism should appear unduly severe.

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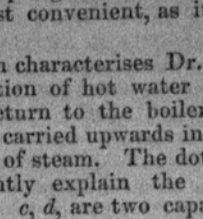
*The High-Pressure Steam-Engine; an exposition of its Comparative Merits, and an essay towards an Improved System of Construction.* By Dr. Ernst Alban, practical machine maker, Plau, Mecklenberg. Translated from the German, with notes, by William Pole, C.E. London: Weale, 1848. 8vo. pp. 150.

This is the conclusion of a work of which the first portion was reviewed *ante*, vol. X., p. 45. It will be remembered, that the distinguishing feature of Dr. Alban's subject is an earnest advocacy of the merits of the high-pressure steam-engine, which, he contends, is for all purposes and under all circumstances, superior to the low-pressure engine. He proposes to increase the steam-pressure greatly beyond the limits now usually assigned to it; and as his observations are the result of long practical experience in the manufacture of engines, and in superintending their working, they are at least deserving of consideration. His arguments are those of a careful and judicious observer, and the details of his experience prove that he has pursued his profession with no ordinary amount of energy and ability.

In the present portion of the treatise, our author describes the form of the boiler and furnace adopted by himself, and which he recommends as models for general adoption. We must demur, however, to the notion of a *model engine*, and to any one routine of construction prescribed for universal practice. The steam-engine would lose much of its value if the arrangement of its parts were immutable. The diversity of forms which may be given to it, and the facility of adapting them to local exigences, render the steam-engine the most convenient, as it is the most economical, of motive agents.




The principle which characterises Dr. Alban's boiler, is the circulation of hot water through the tubes, and the return to the boiler of the water which has been carried upwards in a liquid form with the current of steam. The dots in the diagram will sufficiently explain the relative position of the tubes. $c$, $d$, are two capacious vessels above them. The ends of all of them communicate with $c$, the "separator," into which, therefore, the steam generated, and the water mechanically mixed with it, are carried. At that end of this vessel where steam and water are admitted, violent ebullition goes on; but as the capacity of the boiler is large, the water and steam become more and more separated as they progress to the further end, whence they pass quietly by their respective pipes to the receiver $d$, in which an undisturbed water-level is maintained. From $d$, the steam passes off to the engine, and the water is returned to renew its labyrinthine course through the tubes of the boiler.

Our author assures us that he has determined the efficiency and economy of this invention, by actual and careful experience. The advantage which he claims is, chiefly, that of having a tube surface, subject to the direct action of the furnace, and yet not liable to excessive ebullition or boiling dry. The tubes are of small diameter; consequently, their heating surface bears a higher proportion to the volume of water in them, than would be the case with tubes of a larger diameter. This circumstance, Dr. Alban insists upon as most important for the economical generation of steam. At the same time, the tubes lie so far below the water-level, that a want of water in them is scarcely likely to occur: and if it did, it would take place first in the higher tubes, which are the least exposed to heat.

It will strike some of our practical readers, that this mode of construction, and the smallness of the tubes, must render them exceedingly liable to be impaired by the accumulation of deposit. We are told, however, that this is by no means so formidable a difficulty as it may at first sight appear, as the stony concretion is confined to the upper tiers of tubes, and the arrangement affords easy access to them. It is however allowed, that tubes of so small size as those here described would not be applicable to marine boilers, in which a great deposit from salt water takes place.

After a minute description of the boiler, the writer proceeds to an examination of improvements of the furnace. He does not deem of much importance the "smoke nuisance," as it is emphatically termed in England, and decries the legal restrictions to which engine owners are subjected in Germany, to prevent them from forcing the bituminous vapour and soot of their furnaces down their neighbours' throats. "The English," says he, "continue to live well among their smoke, and find themselves well off on it; they neither turn up their noses nor get asthma, but they live, and live long." We, however, who live in England, are not easily to be persuaded that the vitiation of the air by smoke is a slight evil. The pollution of the air in London and the manufacturing districts, inflicts mischief of which the magnitude can only be appreciated by actual observation. The cities of the continent, by the limits of their size, and the comparative insignificance of the manufactures carried on in them, are so little subjected to the injury in question, that it is not surprising that a foreign writer should speak slightingly of it. But the thousands who annually fall victims to the chimney-polluted atmosphere of this metropolis, give mournful proof that it is no false sentimentality—no popular prejudice, that have at length rendered the sanitary regulation of manufactures an irresistible obligation on the legislature. Dr. Alban considers all the self-acting contrivances for consumption of smoke useless; and deems it vain to expect that any future inventions for the purpose will succeed. It is sincerely to be hoped, however, that an object of such paramount importance will not be given up in despair. There can be no question that much improvement has already been effected, and that the combustion of fuel is conducted in a more complete and perfect manner now than it was a few years ago. When the necessity of further exertions becomes apparent, that parent of invention will stimulate our mechanicians to further exertions, and to the discovery of methods which, we are convinced, have not yet been attained, because the inquiry has been partially or feebly conducted.

The subject next considered is the engine itself, in which several improvements are proposed. According to our author's principle of confining himself to one exclusive model for every part of the steam-engine, he here selects the oscillating-cylinder for universal adoption. The history of these cylinders as given by the translator is curious, and affords interesting testimony that a discovery, after being abandoned by the original inventor as useless, may be taken up by others with complete success. In 1802, TREVETHICK took out a patent for an engine, in which cylinder, boiler, and furnace *all swung together;* and adds, that if it be desirable, *all the other parts may be fixed except the cylinder, which may be suspended on trunnions or pivots perforated for the admission of steam.* Other patents were also taken out for moveable cylinders; but the first oscillating-engines actually made, were those of Mr. AARON MANBY, and his son, the present able secretary of the Institution of Civil Engineers. The important addition of the slide-valve was patented by JOSEPH MAUDSLAY, in 1827; who, by combining the D valve with eccentric gearing, made an important step in perfecting these engines.

Dr. Alban proceeds to discuss the several objections usually urged against the the oscillating-cylinder, and to explain its advantages. To the objection, that injurious lateral strains are produced every time the motion is reversed and the momentum arrested, he replies, that in steam-engines of ordinary construction, the parts subjected to reciprocating motion (the beam or side-levers) are usually heavier than the cylinder, and vibrate through a much greater arc. Though this be true, we must remark that the arrangement of the oscillating-engine renders it mechanically, or rather geometrically, impossible that its motion can be so even and regular as that of the beam-engine. By the arrangement of the ordinary crank, the motion of the beam is slowest at the two limits of its motion: it comes gradually to rest at the extremity of the arc of vibration, so that every thing like concussion is avoided: and that this advantage is attainable in the most perfect degree, is proved by the fact that in properly constructed engines, the most ponderous beams move without producing a jar or concussion. In the oscillating-engine, however, there is a peculiarity in the arrangement which precludes uniformity of motion. The arc through which the crank revolves while the cylinder oscillates in one direction, is less than a semicircle—and greater than a semicircle while the cylinder oscillates in the contrary direction. Hence, if the motion of the crank be uniform, the cylinder oscillates from right to left, and from left to right, in unequal times. If, on the contrary, the oscillations of the cylinder be regular, the crank moves faster when it is near the cylinder than when at its greatest distance from it. In practice, these two variations are compounded—or, if the phrase be allowable, the irregularity of motion is *shared* between the crank and the cylinder. Of course, the motion of the piston and other parts is affected by it. The actual amount of it depends on the relation between the length of the crank and connecting-rod, and the distance of the trunnions of the cylinder from the centre of the crank; and, *cæteris paribus*, the uniformity is increased by increasing the distance of the swing centre from the crank-shaft: but perfect regularity is unattainable.

To the objection, that the cylinders are unequally worn by the piston pressing first on one side and then on the other, the author replies, that this objection can only apply with much force where the pistons are large and heavy, and that the hemp packing (which he always prefers to metallic packing) almost entirely remedies the evil.

The disadvantage arising from the friction of the trunnions on which the cylinders swing, and which are usually perforated for the admission and eduction of the steam, is remedied by the author by suspending the cylinders—not on the gudgeons through which the steam passes—but on a separate frame, having no communication with them. After enlarging on the great increase of friction resulting from the heat of the metal, he shows that by keeping the actual bearings on which the weight of the cylinder is supported, separate from the steam passages, the heat of the rubbing parts is comparatively trifling, and that a great amount of friction is consequently avoided.

The fourth objection considered is, that "when the distance of the trunnion-axis from the crank-shaft is too small, the vibrations are unequal, as is also the force transmitted to the engine." To this remark the translator briefly replies, in a note, that "the objection has no weight at all." With great deference to Mr. Pole's authority, there is considerable weight in the objection. He has not appended to his *dictum* any reasons in defence of it, and there is therefore hardly any other way of meeting him than by counter-assertion. Does he mean to assert that the vibrations are performed in equal times? If so, it is quite clear, from the geometry of the case, that the crank moves at variable rates; and this is sufficient proof that the force is not uniformly transmitted to the working parts. If, on the other hand, the motion of the crank and the transmission of force be uniform, the oscillations of the cylinder take place in unequal times. There is no escaping from one or other of the horns of the dilemma. We do not insist on the disadvantage as necessarily serious; but that it exists, and is unavoidable, is obvious from mere inspection of a diagram showing the relative positions of the cylinder and crank.

The advantages of the oscillating-cylinder on which our author earnestly enlarges, are—1st, its simplicity, arising from the omission of the beam, parallel motion, and other parts; 2nd, the facility of construction, the fitting being in a great measure effected by the lathe; 3rd, compactness, and consequently suitability for steam-vessels; 4th, comparative lightness; 5th, the consequent portability; 6th, diminution of prime cost; 7th, the simplicity of working management; 8th, the diminution of friction; 9th, the saving of grease for lubrication; 10th, the little repair required; 11th, the facility of discovering and rectifying any error of adjustment; 12th, the omission of guides for the piston-rods; and lastly, the direct and advantageous transmission of force.

There is one remark to be made on this enumeration of the advantages of the oscillating-engine, which, though simple, deducts greatly from its claims to pre-eminence.—The greater part of the merits claimed for it do not belong to it exclusively, but are common to all kinds of direct-action engines.

Among the prominent features of Dr. Alban's views, is the preference which he tells us that long experience has induced him to assign to hemp packing for the piston. Contrary to the opinion of many practical men, who believe the metallic packing absolutely indispensable for high-pressure engines, he considers that method fraught with inconvenience. It may however be observed, that many of the disadvantages (those arising from imperfect workmanship) are more likely to arise in Germany than in England, where we may justly pride ourselves on the marvellous perfection which has been obtained in the manufacture of the details of the steam-engine.

Other objections to metallic packing are not to be thus disposed of. The cylinder and the piston are frequently of different metals, and therefore liable to different rates of expansion; consequently, the adjustment of the packing, though perfectly accurate when the metals are cold, becomes untrue after they are heated. Dr. Alban denies that the packing grinds itself steam-tight by working; on the contrary, he believes that if any imperfection exist originally, it is aggravated by use. We are however inclined to believe that he speaks on this point from limited experience, for while the elasticity remains unimpaired, it presses against the cylinder any irregular protuberances which may exist, and the adjacent parts are protected from attrition till these be worn down to an even surface. Of course, if the elasticity of the packing be unequally distributed, those parts most forcibly pressed against the cylinder will wear thin and be destroyed before the portions of the packing subjected to less pressure.

The liability of the packing to lose its expansive power, either by the component parts cohering and losing their mobility, or by the heat destroying the elasticity of the springs, is strongly insisted upon. It is also asserted that the complexity and number of the parts render them liable to get out of repair, and that they can never fit so closely as to be perfectly steam-tight. Hemp packing is preferred on account of its simplicity; and the author states, as the result of his experience, that a packing of rope, of loose unspun fibres, thoroughly lubricated, works well and remains steam tight under high pressures. We will not absolutely assert that there are not any circumstances under which this kind of packing may be used with advantage, but many of Dr. Alban's prejudices must have arisen from observing the working of metallic packing of inferior construction; and probably, if he were acquainted with the great improvements which have been effected in England in this part of the steam-engine, he might be induced to modify his opinions.

There are many other topics of the treatise before us deserving attention, but we must content ourselves with remarking, generally, that the very original views taken by the author are not those of an ingenious schemer merely, but of one who combines originality of invention with practical knowledge, and enhances both by the power of logical induction exhibited in the methodic arrangement of his arguments, and the distinct statement of the results of his experience.

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*The Assistant Engineer's Railway Guide.* By W. Davis Haskoll, C.E. Part II. London: John Williams and Co., 1848.

Many excellent works on subjects connected with the profession of the civil engineer have at various times been published. But while the wants of the more advanced portion of the profession have been comparatively well supplied, the junior members have been left, at their entrance on the practical duties of their calling, almost without any guide to assist them. The need of a book, treating in a practical manner of the minor, though most important, operations which form the principal duties of the assistant engineer, has long been felt; and we are glad to find that this requirement has been satisfied by Mr. Haskoll, in the work before us.

In the first part, published in 1846, the subjects of setting-out the centre line, taking the permanent section, boring, and the other operations preliminary to breaking ground, were discussed; in the second part, the author has devoted his attention to the setting-out of works, the subject of earthwork, the formation of the permanent way, and the many operations necessary while the railway is in progress of construction. These various topics are treated in a clear and practical manner: every variety of work, whether on the skew or square, on a straight line or curve, is considered; and the methods of setting-out, and the precautions necessary during the construction are shown. The author is no advocate for the "rough-and-ready" system, but inculcates a careful attention to accuracy in every particular. Were this course more commonly adhered to, we should not so often hear of failure in works, causing often loss of life, and always profuse expenditure of capital. The following passage will illustrate the author's views on this subject:—

"Let me persuade the young practitioner, that the gratification he will feel at finding the string-courses of his bridges and viaducts at their true height and gradient, or the formation of a tunnel at the intended levels, will alone amply reward him for his trouble, independently of a reputation for accuracy, which he will not fail to obtain in the opinion of a judicious chief, as also in the estimation of directors. Let him beware of the vaunts of 'rough-and-ready' men (*rough* work and *readiness* to blunder), who disguise their incapacity and ignorance, by pleading the impossibility in practice to obtain truly correct levels; for if there be any truth, rationally speaking, in this excuse, the greater should be the engineer's care to avoid errors, and not to do his work in a slovenly manner, whereby he may double and treble his '*mistake*;' and he will find that contractors, masons, bricklayers, &c., will be careful and attentive, exactly in proportion to the care and attention which he himself bestows on the works. This observation applies exactly in the same sense, and to the same extent, in setting-out works. He will, moreover, have the satisfaction of knowing, that his mind on this subject will be at ease as the works proceed, and that no reproach can be made to him; on the contrary, an error of this kind carried out can be considered little better than wilful neglect of duty."

After giving an example of a section book, containing columns for the half-widths, distance, total rise, finished levels, excavation, and embankment, on one side,—with a sketch of the surface, and notes of the position and particulars of bridges, culverts, &c., on the other,—the author adds the following hints:—

"The pocket section being prepared so far, we should, as soon as the works of construction are determined on, insert notes from the working drawings, or otherwise, of the angles of skew at which the line crosses roads, canals, &c.; the spans of arches on the square and skew, the rise of the arch, the depth of arch stones, of puddle, if any; also, if the works be on an inclined plane, the rise or fall from centre to centre of piers; memoranda also, of nearly similar nature, should be made of girder bridges, culverts, drains, and other works occurring along the line. These remarks are more than necessary; because, when on the works, the drawings, when required, are often mislaid, or partially defaced or destroyed. It must be added, however reluctantly, that the tracings with which contractors and sub-contractors are supplied, are often wrongly figured; and the site of construction, amidst the moving to-and-fro of masons, labourers, and 'navvies,' is not the place where such errors may be most readily detected and corrected."

The second chapter is devoted to earthwork; and here the author shows a practical acquaintance with the numerous considerations that determine the course to be taken in the treatment of this most important feature of the works of a line of railway. We subjoin a few extracts on cutting and embankment:—

"The determination of slopes for earthwork is one of the most uncertain subjects the engineer has to contend with, if he be anxious to reduce as much as possible the quantity of excavation, and that of land to be purchased—both formidable items of expense: but this reduction is attended with one great danger—namely, a 'slip,' which will often, for a considerable length, occasion a double and treble quantity of excavation, and the purchase of a corresponding quantity of land. * * * The slopes of cuttings in gravel will stand at almost any depth at 1½ to 1, and at depths of 10 feet and 15 feet at 1 to 1;—chalk is more uncertain; in solid rocky masses, it will stand perpendicular; friable, it may require slopes of 1 to 1;—shale will stand at a ¼ to 1, if the stratification be horizontal and dry, but when wet and soapy, there will be great uncertainty;—clay, however, is by far the most uncertain and treacherous earth to be met with in excavating; we have known it for many months to stand perpendicular for a depth of 40 feet, and suddenly slip off, determining a slope of 3 to 1; there is no doubt, that one of the most dangerous practices of excavators is to allow a gullet of this depth and nature to stand for a great length of time without lightening the sides, nor should it under any circumstances be allowed. A thin bed of clay will very often occasion the slip of material of a better nature. * * * When a slip has once fully declared itself, there is little left but to submit to the circumstance, and to form the slope to the extent determined by the slip; except, indeed, in the case of buildings, or gardens, &c., when we must have recourse to retaining walls and long counterforts, with a good system of drainage, which will always be found indispensable; so much so, that no good results can be expected from the best built and thickest walls without it."

"The best materials for the formation of embankments are gravel and sand, both from the facilities they offer for drainage, and their more rapid final consolidation;—*soft*, shaly earths are unfavourable, but if hard and dry they form good embankments, and settle well at slopes of 1 to 1;—vegetable earths, or what is termed soil, must be entirely rejected for the embankment, from their being so easily converted into soft mud; landowners, however, are always ready to carry these away, but care should be taken to preserve a sufficient quantity for soiling slopes, as when a good depth of soil has once produced a strong vegetation, it forms one of the best safeguards to slopes;—clays mixed with a quantity of stones, are by no means a bad material, and if dry, will form a sound embankment, though rather long in consolidating;—wet clay is as bad as peat, if not worse; it should never be allowed to be used under any circumstance whatever; a few wagons of wet clay, tipped in a deep embankment, will do more mischief by its slipping, and saturating all other materials laid on it, than one or even two thousand of good stuff will rectify, besides becoming for many years a continual source of settlement, and perhaps of danger, on that portion of the line. Where the less favourable materials must be employed for forming embankments, it is as well to make an exception to the general rule, of forming at once an embankment to its full height and width, and to leave a few feet in height to be raised up with drier materials, *if conveniently at hand*; isolated masses of this description are often found in excavations, otherwise of very inferior materials, which may be successfully employed for this purpose."

Two tables are given at the end of this chapter, which will prove of great assistance in estimating earthwork. The chapter on setting out of works goes very completely into the whole subject, and will render most valuable assistance to the young beginner; indeed, the information therein contained can be found in no other book than the one before us. After tables of experiments, by George Rennie, Esq., on the strength and other properties of various materials, now for the first time published, are given the specification and drawings of a very elegant and scientifically, designed laminated arch, over the river Ouse, on the East Anglian Railway, designed by J. S. Valentine, Esq.; and at the end of the book are placed many tables of a useful character.

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*Facts and Evidence Identifying the Authorship of the Letters of Junius.* By John Britton, F.S.A.

Mr. Britton, who takes in a wide range of subjects in his antiquarian ken, has added a new book to the many on the *vexata questio* of the authorship of "Junius." He favours Colonel Barré. This discussion does not come within our scope,—but it does to record the labours of one who has contributed so much to architectural literature.

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*Irish Wants and Practical Remedies; an Investigation on Practical and Economical Grounds, as to the Application of a Government System of Railways in Ireland.* By HUMPHREY BROWN, Esq., M.P. London: Barnett, 1848.

Many of our readers will care very little about a system of railways for Ireland, though this little work deserves attention for what it says on that subject; but it requires notice as being the only attempt yet made to apply statistically to a given case the doctrine that railways can be made by means of existing resources, and that they are of a reproductive character. An additional value is given to it, that it contains the latest statistics on railway subjects, and many novel applications of them.

Among the chief points discussed, are the number of persons temporarily employed and permanently employed; the saving and reproduction on agricultural resources; the effect of extending the area of supply by extending the radius of communication; the average contribution and mileage of each head of traffic; the pecuniary or capital resources of Ireland; the correspondence between traffic estimates and traffic returns; and the existing traffic on Irish lines of road.

The following is a curious illustration of railway economics, and supplies evidence on a question which has been often mooted :—

"Mr. Porter, in the new edition of his work on the Progress of the Nation, p. 30, has given a table of the estimate of traffic given to parliament by several railways, and by appending to them the actual traffic from the returns made in 1845, we shall be able to see how far the estimates have been borne out.

The estimates for the railways constituting the Midland Railway, are as follows :—

| | Passengers. | Cattle. | Sheep. | Merchandise by Land. Tons. | Coals by Water Tons. |
|---|---|---|---|---|---|
| Birmingham and Derby | 145,747 | 7254 | 27,105 | 14,547 | — |
| North Midland | 149,812 | — | — | 124,350 | — |
| Midland Counties | 255,424 | — | — | 12,948 | 285,000 |
| Total estimated | 550,985 | 7254 | 27,105 | 151,855 | 285,000 |
| Midland Railway, 1845 | 1,809,145 | 30,000 | 120,000 | 371,154 | 313,854 |

The Midland Railway traffic included, likewise, 30,000 pigs, and 56,290 tons of lime. The merchandise carried by water was estimated at 255,738 tons, and this, and a great quantity of coals, are still carried by water, so that the railway has, as it were, created an amount of traffic.

The estimates and returns for the Manchester and Leeds Railway stand thus :—

| | | Merchandise by Land. Tons. | Total Goods by Land and Water. Tons. |
|---|---|---|---|
| Estimates | 207,588 | 166,486 | 358,958 |
| Returns | 1,674,946 | 507,852 | — |

Thus the traffic on the railway is greater than all that previously moving by land and water, although the canal traffic is as great as before.

The estimates and returns of the York and North Midland Railway stand thus :—

| | Passengers. | Merchandise by Land. Tons. | Merchandise by Water. Tons. | Coal by Water. Tons. | Cattle. | Sheep. |
|---|---|---|---|---|---|---|
| Estimates | 185,660 | 5547 | 95,100 | 98,000 | 53,000 | 110,600 |
| Returns | 461,755 | 351,022 | — | — | 15,364 | 87,639 |

The traffic in this case resembles that of the Manchester and Leeds, in its results.

The following are the estimates and returns of various other railways:—

| | | Passengers. | Merchandise. by Land. Tons. |
|---|---|---|---|
| London and Brighton | Estimates | 226,444 | 43,765 |
| | Returns | 788,386 | 65,747 |
| South Eastern (1847) | Estimates | 317,252 | 63,079 |
| | Returns | 1,477,892 | 204,100 |
| Great North of England | Estimates | 75,158 | 32,136 |
| | Returns | 196,722 | 234,198 |
| Great Western and Bristol and Exeter (1847) | Estimates | 821,145 | 150,710 |
| | Returns | 3,876,222 | 371,326 |
| Lancaster and Preston | Estimates | 106,957 | ——— |
| | Returns | 135,344 | 26,099 |
| Glasgow and Ayr | Estimates | 597,470 | 121,027 |
| | Returns | 834,078 | 168,376 |

This will be found useful as a book of reference, on account of the facts and figures it contains, and the mode in which they are applied, as it is the only work which has yet embraced the subject of railway traffic in a practical and comprehensive manner.

## REGISTER OF NEW PATENTS.

### REDUCTION OF COPPER ORES.

CHARLES LOW, of Roseberry-place, Dalston, Middlesex, gentleman, for "*Improvements in the manufacture of zinc, copper, tin, and other metals.*"—Granted November 4, 1847; Enrolled May 4, 1848

The title of this patent is more comprehensive than the specification, as the patentee disclaims all parts of the title, excepting that relating to copper. The object of the improvements is to quicken the manufacture of copper from its ores, and to diminish the loss of metal. In reducing the ores a compound is employed, consisting of oxide of manganese, plumbago, nitrate of potash, nitrate of soda, or lime, and carbon. The proportions of these materials the patentee states to be, oxide of manganese forty-two parts, plumbago eight parts, nitrate of potash, nitrate of soda, or lime, two parts, and carbon fourteen parts; the carbon to be used, the patentee prefers to be either anthracite coal or wood charcoal. The mode of operation is as follows: the ore is roasted in the usual manner and then melted; and when in this state, the composition of the four materials named is introduced into the furnace and well mixed with the melted ore. The composition is introduced in the proportion of twenty-five pounds weight to one ton of ore operated upon, and acts as a flux. The slag rises more rapidly than ordinary to the surface of the melted mass, and is then to be skimmed off. When the workman perceives the metal is in a sufficiently forward state of manufacture, a second quantity of the composition in equal proportions is added, and the mass is again stirred and skimmed. Additions of the composition are repeated if necessary, until the copper is in a sufficient state to be removed and operated upon in the usual manner. Should it be considered desirable, the composition may be introduced at any of the subsequent meltings of the ores, either in addition to, or without being introduced at, the first melting. The patentee does not confine himself to the precise proportions specified of the materials, nor to the precise mode of operation described, but claims the employment of the compound of oxide of manganese, plumbago, nitrate of potash, nitrate of soda, or lime, and carbon.

### DRESSING ORES OR MINERALS.

WILLIAM BRUNTON, jun., of Poole, Cornwall, civil engineer, for "*certain apparatus for dressing ores or minerals.*"—Granted November 16, 1847; Enrolled May 16, 1848.

This invention consists in the application of centrifugal force combined with the upward impulse of water in the dressing of small ores. The first part of the apparatus consists of a tank from five to six feet square; within this is fitted a sieve, having a wove wire or perforated metal bottom, the apertures being adapted in size to the ore about to be dressed. This sieve is fixed upon an upright shaft or spindle, revolving in a bearing at the bottom, and having a turned journal at its upper end. The depth of the annular margin or sides of the sieve is about eight inches. Immediately under the bottom of the sieve a partition, enclosing about one-third of its area, crosses the tank, and having communication with the discharge pipe of a force-pump. On the opposite side of the tank is a receptacle for the ore, and this is supplied by an instrument termed a "skimmer;" its lower end forming a mouth, and equal in breadth to the semi-diameter of the sieve; the stem being hollow, and bent at a certain portion of its length (turning downwards), so that anything passing through it will be deposited in the receptacle attached to the tank. A rotating motion being given to the sieve by means of wheels and pulleys fixed upon the upper end of the upright spindle, and the sieve being charged with ore or mineral by means of a hopper placed above it, the mouth of the skimmer is so regulated that, as the whole revolves, the water is forced upwards through the sieve by the action of the force-pump. The ore, by excess of weight, falls through the bottom of the sieve into the tank, and the waste is carried into the mouth of the skimmer, in consequence of the rotating force, and passes thence through the pipe or stem into the adjoining receptacle. The stream of water which is carried with the waste returns into the tank, and is sufficiently clean to be used again. The area of the piston of the pump should not be less than one-third the area of the sieve, and from 60 to 100 impulsions should be given by the pump before the skimmer is set to work; by this means the particles are raised, separated, and adjusted according to their specific gravity and bulk. Should the "orey" stuff be larger than the apertures of the sieve, the feed from the hopper is shut off by a little door that closes its mouth, and a shoot being placed on or

under the lower end of the stem of the skimmer which is lowered to take up the ore, it then passes through the stem into any receptacle placed to receive it. By another arrangement of the machine the skimmer revolves instead of being fixed, and traverses the ore at a regulated depth from the surface, and the waste is carried by the rotating force and the stream of water into the skimmer, and from thence into the central compartment, from whence it passes down the hollow shaft into the receptacle appointed to receive it. The second part of the invention relates to a method of dressing small ore and sleines of ore. A hollow frame or trunk, has for its section the exterior form of a cone, which converges to its centre from the extremes of its base, and terminates in an aperture having a cock. To this centre is fixed an iron arm or step, upon which the whole apparatus revolves. The apex is formed like a goblet, for the purpose of a funnel, into which the small ores are poured. On each side or limb of this trunk or hollow frame are attached three receptacles, the first opening from the trunk into the uppermost one, being about one-third from the apex or funnel; the second communicating with the middle one, at about two-thirds from the apex; and the third at the angle or extremities of the base. A pulley is fixed to the under side of the funnel, by which a rotating motion is imparted to the whole of the hollow frame, and the small ores in a moistened state are poured into the funnel, and pass down the hollow trunk. The centrifugal force of the revolving trunk causes the heaviest of the ores to be discharged at the upper opening into the adjoining receptacle; the next less in size into the middle one, and the least, or sleines, into the lower one. The water which passes into the trunk with the small ore or sleines of ore, is discharged by means of the cock at the base, immediately above the step upon which the whole revolves. When the receptacles are full, the small doors in front of each are removed, and the ores are taken out and placed in the usual bins, according to their various sizes. The patentee claims—first, the conveying the ores and waste into another receptacle over the annular margin of the sieve, by means of a skimmer-pipe and stream of water; secondly, the application of the force-pump; and thirdly, the application of centrifugal force for producing artificial gravitation.

## MANUFACTURE OF PIGMENTS.

William Edward Newton, of Chancery-lane, for "*Improvements in the mode or modes of manufacturing or preparing certain matters to be employed as pigments.*" (A communication.)—Granted November 16, 1847; Enrolled May 16, 1848.

This invention relates to the manufacture of zinc-white, zinc-yellow, and zinc-green, though it is principally directed to the formation of zinc-white, the other pigments having been the subjects of a former patent. The processes are described at great length in the specification, but the claims of the patentee will sufficiently explain the nature of the proposed improvements. He claims—First, the distillation of metallic zinc, of oxide of zinc, or zinc ore, by one of several means mentioned. Second, the application of furnaces similar to glass furnaces and coke ovens, and the modification of them respectively in order to fit them for the purpose of manufacturing zinc-white. Third, the construction of furnace, formed of two cylindrical tubes placed side by side with furnaces or fire-places formed in the lower part of the brick-work. Fourth, the isolating the retorts from each other and also cutting off the communication between the retorts and the oxidizing chamber when required. Fifth, the employment of suitable apparatus for cleansing the mouths of the retorts without being obliged to enter the oxidizing chamber. Sixth, the arrangement of apparatus by which the retorts may be charged, cleansed, and replaced, or submitted to any operation required, without interfering with the oxidizing chamber. Seventh, the application or employment of blast furnaces for the production or manufacture of zinc-white or oxide of zinc, whether such furnaces are circular or of any other suitable form, and whether they are constructed and arranged in a vertical, inclined, or horizontal position. Eighth, the employment or introduction of currents of air into an oxidizing or other chamber, for the purpose of converting the metallic vapours of zinc into zinc-white or oxide of zinc; also the employment of an exhaustion-tube or blowing-apparatus for conducting the metallic vapours to the oxidizing chamber. The patentee claims also the employment of wire-gauze or sieves for sifting the products; also the arrangement of vessels for receiving the heaviest portions of products. Ninth, the arrangement of the oxidizing chambers so as to allow of the products being collected without the necessity of entering them. Having described all that appertains to the manufacture and manner of collecting zinc-white, the patentee next proceeds to an explanation of that part of the invention which relates to the yellow of zinc and green zinc. As the manufacture of zinc-yellow forms the subject of a previous patent, he merely remarks that hydrochloric acid may be used instead of sulphuric acid. To form zinc-green, yellow (having been produced by the patented process,) is diluted with a suitable quantity of water, and mixed with a certain quantity of prussian blue (previously mixed with a suitable quantity of water, oil, or other appropriate liquid), either in a hot or a cold state. Green of zinc will thus be formed, the colour of which will be as durable as the blue itself. These pigments may be employed for painting of any kind.

## SMELTING COPPER ORES.

William Birkmyre, of Southdown, Cornwall, for "*Improvements in smelting copper and other ores.*"—Granted November 16, 1847; Enrolled May 16, 1848.

The chief object of this invention is to remove the nuisance arising from the sulphuric and sulphurous acid vapours, and from the vapours of arsenic, during the smelting of copper ores. The process is thus described:—A double iron pyrites kiln is constructed upon the usual principles, the ash-pits being furnished with a leaden cistern, filled with water, to abate the nuisance arising from the sulphurous and arsenious acids, when drawing out the mundic ashes. Over the charging-door for the mundic, is an air-hole, provided with a damper, to regulate the passage of the oxygen necessary for combustion. The size of the double iron pyrites kiln should be 13 feet long, 7 feet 4 inches wide, and 8 feet high, and each furnace should be 5 feet in diameter, and of an octagonal form, lined with fire-bricks. Above the charging-door for the mundic, resting on two or three bars, is a tray, made of iron or copper, 4 feet 6 inches long, 3 feet 6 inches wide, and having a rim round it three or four inches deep. This is so placed as to enable the air and acids to pass freely out of the top of the furnace into a vitriol chamber, which is placed over the kilns. The vitriol chamber should be 150 feet 6 inches long, 11 feet 3 inches wide, and 9 feet deep, divided into three compartments, technically called "bottoms." The acid in that compartment nearest to the kiln being impure, should be kept apart, but the acid in the second and third compartments will be found to contain good vitriol. These pair of kilns will be found capable of producing two tons of copper per diem, by means of mundic, and, at the same time, of three tons of vitriol of a specific gravity of 1·847. The copper ore being broken into pieces, about the size of walnuts, is put into the tray by means of a shovel or hopper (the furnace being charged with iron pyrites and previously kindled). After a lapse of six hours the other kiln is to be charged in like manner, and so on alternately. For every 8 cwt. of mundic containing 40 per cent. of sulphur, as charge of 10 cwt. of mundic containing 40 per cent. of sulphur, as for every 32 parts of sulphur it loses, it gains only 12 parts of oxygen; but in copper ores, if the process is carefully completed, it gains as much in oxygen as it loses in sulphur; some copper ores it is stated will gain as much as four per cent. About 1½ cwt. of ore should be placed in the tray, and the charge should be spread out into a body of from one to two inches thick, which should be turned over now and then, in order that every part of it should be exposed. After being submitted to the process for one hour, it is to be turned into a leaden cistern, supplied with hot water from the cooling cisterns underneath the kilns, to undergo the process of lixiviation. The tray is then again charged with ore, and the process is continued. It requires two roastings and lixiviation by the electro-metallurgic process to obtain the pure copper. Another method of calcination is, when the pulverized copper pyrites are exposed in the tray, pour upon them a hot solution of nine parts of saltpetre, and eight parts of cubic nitre, or 16 per cent. of saltpetre and 10 per cent. of vitriol, or equal quantities of saltpetre and vitriol to half the quantity of the ore. By this system, the deutoxide of nitrogen, necessary for making vitriol on a large scale, is separated, and the oxidation of the ores accomplished. The patentee claims—First. the roasting separately common ores of copper and other metals, by exposing them in an open vessel in a mundic-kiln, so that the vapours shall freely mix with the vapours of combustion of the iron pyrites, and be condensed at the same time in the vitriol chamber. Secondly, the separating simultaneously the deutoxide of nitrogen, for the vitriol chamber, with the oxidation of the ores, by saltpetre or cubic nitre. Thirdly, the supplying the vitriol chamber with steam, by using saltpetre or cubic nitre; and, fourthly, the action of sulphuric acid upon the ores, either before or after they have been freed from the sulphate and arsenic of potash and soda.

## ROTARY ENGINES.

ISRAEL KINSMAN, of Ludgate-hill, London, merchant, for "*Improvements in the construction of rotary engines, to be worked by steam, air, or other elastic fluid.*" (A communication.)—Granted November 11, 1847; Enrolled May 11, 1848.

The principal feature in this form of rotary engine is a "piston wheel," provided with any desired number of pistons upon its periphery. The pistons are formed radially from the centre of the piston-wheel, and bear and work against the interior of a stationary cylinder. From the curved periphery of the piston-wheel to the interior of the stationary cylinder, there are stops which pass into the cylinder, the ends of which bear against the periphery of the piston-wheel or the pistons, and thereby render that portion steam-tight. The peculiar form of the pistons enables the stops gradually to recede from the interior of the cylinder until they become flush with the interior surface of the cylinder, and thereby allow the pistons to pass them without obstruction. Immediately that a piston has passed a stop, the stop is again projected into the cylinder to act as a surface, against which the steam acts to propel the piston-wheel forward. The patentee claims—first, the employment of the piston-wheel, upon which the number of pistons shall always be one more than the number of steam-stops on the cylinder, there being one steam-port and one exhaust-port to each steam-stop; the steam acting upon one or more pistons at the same time. Secondly, the mode of moving the slides or steam-stops by a cam or cams, corresponding in form to the periphery of the piston. Thirdly, the connecting all the steam-ports with the steam-pipe, so that steam shall have access to the cylinder at the same time, by the pistons passing the ports. Fourthly, the connecting all the exhaust-ports with the main exhaust-pipe, so that steam may be exhausted from all the ports of the cylinder at the same time by the pistons passing the ports. Fifthly, the connecting all the ports with the steam-pipe, by a branch-pipe provided with a suitable shut-off valve, and also connecting all the exhaust-ports with an exhaust-pipe, by a branch-pipe, also provided with a suitable shut-off valve. Sixthly, the mode of packing the pistons by means of a central metal-piece acting against two side pieces, having bevelled edges.

## COMBUSTION OF FUEL.

RICHARD COAD, of Kennington, Surrey, chemist, for "*Improvements in the combustion of fuel and in applying the heat so obtained.*" Granted November 25, 1847; Enrolled May 25, 1848.

The object of the first part of this invention is to divide the gases and the smoke resulting from the combustion of fuel in the furnace into numerous small streams, by causing them to pass through apertures in the heated fire-bricks or lumps before they pass into the chimney. The great heat of the fire-bricks thus effectually ignites the unconsumed gases and smoke. The fire-lumps enclose the fire-place at the sides, the end, and at the top, through the whole of which are made the apertures or openings which open to the general flue common to all. There is also an aperture over the fire-door to be regulated at pleasure, for the purpose of admitting a supply of atmospheric air in a heated or other state above the fire-bars for assisting the combustion of the fuel and the gaseous products. The second part of the specification relates to reverberatory furnaces, and consists in supplying through numerous apertures in the sides and the ends of such furnaces above the fire-bars, any requisite supply of atmospheric air in a heated or other state, for the purpose of more effectually accomplishing the combustion of the fuel in the fire-place,—the mode of construction described by the patentee being to form a passage or channel around three sides of the furnace, the fourth being open to the hearth of the furnace; this passage or channel is formed within the brickwork of the furnace. The portion between the fire-place and the passage being of fire-bricks or lumps, it is through these fire-bricks or lumps that the apertures are made through which the supply of air is admitted from the passage to the fire-place above the fire-bars. The patentee states he is perfectly aware that atmospheric air has before been admitted into various descriptions of furnaces above the fire-bars; but it has not hitherto been so employed and admitted with respect to reverberatory furnaces. The third improvement noticed in the specification relates to a more effectual and more economical arrangement of apparatus for the heating of water, and for the warming of rooms or buildings. This improvement consists in the mode of arranging the bars at the back of the grate or fire-place to prevent the fire from lying immediately against the tubes containing the water. There are a top and a bottom vessel connected together by these rows of vertical pipes or tubes, through the interior of which there is a communication between the vessels. From these vessels pipes communicate to warm apartments, buildings, or to other similar apparatus. The rows of vertical pipes or tubes connecting the vessels are placed immediately at the back of the fire-place, the flame and heated air passing amongst them in its way to the chimney in front of the rows of pipes; and between the fire-place and the pipes are bars for the purpose of preventing the fire from acting immediately against them. These bars are placed in vertical positions; the horizontal section being convex in front against the fire and angular behind next to the pipes, they prevent the contact of the fire with the pipes; these bars may be composed of fire-clay or of metal, but the patentee prefers the former. Above the fire-place, the front of the flue or chimney is perforated or pierced with a number of small apertures, for the purpose of admitting air to assist the action of the apparatus.

## MANUFACTURE AND PRESERVATION OF TUBES.

PIERE ARMAND LE COMTE DE FONTAINEMOREAU, of South-street, Finsbury, for "*certain Improvements in the process and machinery for making, uniting, and preserving metallic and other tubes or pipes.*" Granted November 18, 1847; Enrolled May 18, 1848.

The specification of this invention is extremely minute in describing the different processes of manufacturing and preserving pipes, and the patentee claims seven distinct improvements, the enumeration of which claims will give a general idea of their character. The invention consists, first, in making and uniting metallic pipes simultaneously, by acting over the top or head of the rivet. Secondly, soldering, laterally, galvanised iron, leaden, and tinned pipes, (either riveted or clasped,) by means of a long thread or fillet of solder. Thirdly, uniting metallic pipes by means of a certain improved clasp. Fourthly, uniting metallic pipes by inserting in the clasps employed for the purpose certain compressible substances for preventing the escape of gas and fluids. Fifthly, uniting metallic pipes, by using a helix for elbowing without flattening the leaden elbow. Sixthly, preserving metallic and non-metallic pipes by the application of resinous matters, fatty bodies, and chalk. Seventhly, in the process of preserving iron and cast-iron pipes from oxidation by means of galvanic action.

## CASTING WROUHT-IRON.

WILLIAM ROCKE, of Dudley, Worcestershire, for "*a new mode of treating and applying wrought-iron.*"—Granted November 18, 1847; Enrolled May 18, 1848.

The object of this invention is to obtain the form required which the facility of casting affords, retaining at the same the qualities of wrought-iron. Having previously prepared the moulds in a similar manner to that adopted in the moulding articles when made of cast-iron, the melted wrought-iron is to be run into the mould. The articles are then of a brittle nature, and deficient of malleable properties, to impart which the patentee next proceeds to treat or anneal them in an annealing furnace. For this purpose the articles are piled in an iron box lined with fire-bricks, leaving sufficient room to surround the articles with a quantity of Cumberland red ore, or other iron ore, or charcoal reduced to a fine powder, the articles being so completely covered as to prevent all admission of the air. In this state they are to be subjected to the required heat for a sufficient length of time to give the required malleability, in which great care must be observed by the workman, and until he has sufficient practice to perform it without, it is advisable to employ a small bar or trial-rod composed of the same metal, which may be withdrawn from time to time, to ascertain the state of the iron and detect the completion of the process, when the articles may be removed. When the density and close compactness of texture obtained by the use of wrought-iron is not required, he mixes a proportion of cast-iron therewith, according to the quality or texture of metal necessary for the article proposed, but in no case to exceed the weight of wrought-iron used; and when it is necessary to impart to the articles manufactured the nature and temper of steel, he mixes with the wrought-iron a portion of cast-steel, but in no case to exceed the weight of wrought-iron employed. These mixtures of wrought and cast iron, or wrought-iron and cast-steel, being melted, are to be cast in moulds, and treated or annealed in the same manner as that described for the manufacture of articles entirely of wrought-iron, when they will be found to have acquired the mal-

leable properties required. The patentee does not claim as of his invention the melting of wrought-iron, this having been practised already to a limited extent; but he claims the treating and applying wrought-iron by melting the same by itself, or with a mixture of cast-iron or steel, and the reproducing malleability in the castings of the molten iron by annealing them in the manner described.

## INLAYING METALS.

Cyprien Marie Tessie Du Motay, of Paris, for "*Improvements in inlaying and coating metals with various substances.*"—Granted November 4, 1847; Enrolled May 4, 1848.

The specification of this patent is exceedingly verbose, and it consists of fifteen articles, showing different modes in which the invention may be applied. The object of the invention is to produce ornamental designs on various articles, by depositing metal thereon after the articles have been properly prepared by marking or cutting out the intended design; and which articles, when finished, have the appearance of being richly ornamented with inlaid work. This method of ornamenting, by inlaying in metal, is known in France as "*damasquinerie.*"

The work produced by this invention is very durable, and not liable to be worn away by cleaning or friction; it being quite equal in solidity to the inlaid work produced by the ordinary means, and even superior in point of finish.

Before depositing the metals intended to form the design, the patentee commences by producing designs, either in intaglio or in relief, upon the body of the article to be ornamented, those parts where no metal is to be deposited being coated with a varnish.

When an inlaying of one metal only is required, the patentee proceeds as follows:—The metal is first cleansed, and then immersed in a bath of the metal, to be deposited by the galvanic current. When the metal has been deposited to a thickness equal to the depth of the hollow parts of the design, it is withdrawn from the solution and washed in water, and dried with sawdust, or by any other convenient means, and the damaskened surfaces are laid bare, by means of freestone, or by filing, scraping, or by any other means which will remove the layer of superfluous metal, in order to uncover the inlaid or damaskened work.

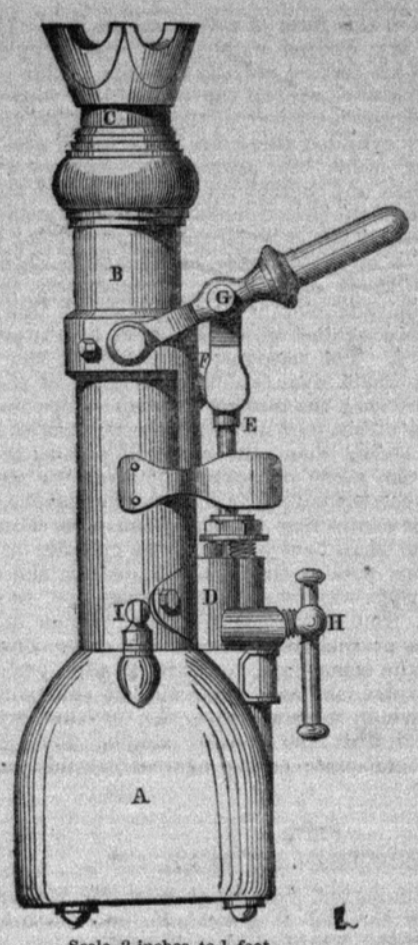
Damaskenes or inlaying in several metals may also be produced by means of pressure. For this purpose, a piece of metal, with an even surface, is covered without soldering, either by immersion or by electro-deposition, with several coats of different metals; each of these layers is of a certain thickness, according to the depth of the parts of the die which are in relief. The last coating being deposited, the piece is to be withdrawn from the last solution, washed, and wiped dry. When dry, it is to be submitted to the action of pressure or stamping by means of dies or matrices, the intaglio parts of which are of equal depth and the reliefs of different heights, or reliefs of equal heights and intaglios of various depths. These must be calculated in such a manner, that, by reason of the penetration of the projecting parts of the die to a greater or less depth, the layers of metal (being, in certain parts, thereby driven to greater or less depths) may, on the surface being laid bare, be of the same level as the inlaid surface.

In order to produce devices or ornaments to be inlaid in wood, marble, &c., by the ordinary means, the patentee proceeds as follows:—He takes a plate or sheet of any metal, and coats it, first, with a layer of copper, of suitable thickness; then with a coating of zinc; and upon that another of copper: and so on until the desired thickness is obtained. As the successive coats of metal entirely cover the tin core, parallel layers of metal are thus obtained, which differ from each other, both as regards the different kinds of metal and their various thicknesses. On cutting the sheet thus produced into thin strips, in the direction of its thickness, designs will be produced consisting of parallel lines of tin, copper, and zinc. With regard to other devices or ornaments, such as roses, stars, circles, &c., these can be produced by taking a metal core, of a certain length, either solid or hollow, and of the form desired to be produced, and coating it with successive and alternate layers of different metals; and when these deposits have been made to the required thickness, they are cut into thin discs. If the core, of whatever form, or metal, be solid, the parallel layers of metal will only be on its outside; but if it be hollow, they will also be inside, as the metal will be deposited on both sides.

## HYDRAULIC LIFTING-JACK.

*Registered by* Mr. Simmons, *and Manufactured by* Messrs. Thornton and Sons, *of Birmingham.*

Under the head of the proceedings of the Institution of Mechanical Engineers at Birmingham, in the *Journal* for March last (page 87), we gave a short account of this jack, and now are enabled to give an engraving of it, which better explains its use. It is stated by the inventor, that one man with the jack can lift from 15 to 20 tons.



Scale, 2 inches to 1 foot.

A is a hollow vessel forming the base of the jack, and also a reservoir for the water. B, the cylinder; C, the ram; D, the pump; E, the plunger; F, the slide; G, the pump-levers; H conical pointed pin; I, a small air-tap. Before using the jack, tighten the pin H, and open the air-tap I. When it is requisite to lower the weight, slacken the pin H. When the jack is not in use, close the air-tap I. Should the water get too low, take out the tap I, and fill the cistern when the ram is down. The ram can be pressed down by hand when the pin H is slack.

For the purpose of increasing the leverage of the pump-lever G, an iron bar about 3 feet long, with a socket at one end, is fitted on to the lever G.

## Mr. WHISHAW'S TELEGRAPHIC INVENTIONS.

We were present in the course of last week at a private view of the numerous contrivances invented by Mr. Whishaw for telegraphic communications. A great part of these inventions apply only to the communications at short distances, and of these an improved speaking tube is the most readily available. The improvements consist in using gutta-percha tubes of various diameters, and in applying removable whistles at each end, to afford a convenient means of calling attention when a communication is to be made. In a tube, two hundred feet long, coiled round so that the two extremities were near each other, the facility with which sound is transmitted was very strikingly exemplified. The slightest effort of the breath sounded a whistle instantaneously, and by blowing at one end, a musical instrument was played at the other as readily as if it had been applied to the mouth.

The chief peculiarity of the telegraphs exhibited, is the application of moveable "codes" to the face of the same instrument; each code consisting of all conceivable questions and answers on any given subject. The fixed dial contains the letters of the alphabet, the titles of the codes to be referred to, and several questions and answers of common occurrence, or most likely to facilitate the communications. The index of the dial may be moved by electrical agency or, for short distances, by mechanism, to be worked by the hand; and when the subject matter contained in any of the codes is to be communicated, the operator causes the index to point to that code marked on the dial. The codes are printed on large card-boards, and have circular apertures in the

centre, through which the index and dial can be seen when placed on the instrument. The questions and answers are printed radially, so that a great number are contained within the range of the index in its circuit; and as it stops at any one, a whole sentence may be at once indicated. Should any word not on the code be required, the index is made to point to the word "spell," and afterwards it indicates the letters of the alphabet that form the word to be communicated. One plan of operating is by water-level indicators, the water in two vertical tubes being elevated or depressed till it stops at the signal wanted. Another telegraph, which however requires great delicacy in the manipulation, consists of two chronometers, each of which has a long second hand pointing to radially-placed words and sentences on the dial. It is essential to the accuracy of the working, that the two chronometers should move sychronously, for if there be the least deviation, it would transmit incorrectly. Supposing that the hands on the two dials at a distance from each other, are always pointing to the same words, in their revolutions,—whenever the transmitting instrument points to the sentence required, the operator is instantly to sound a bell at the distant station by means of electricity; and the observer there must notice at what sentence the hand is pointing when the bell sounds. If both operators be not very prompt in making and observing the signals, a wrong message would be communicated. This difficulty, however, Mr. Whishaw thinks may be overcome, and he has had much practical acquaintance with the difficulties in working telegraphs during a connection of some duration with the Electric Telegraph Company.

## THE "ART-JOURNAL" *versus* ARCHITECTURE.

Not content with excluding architecture, and all notice of it from his columns, although he brings mere industrial art, as it is called, prominently forward, showing numerous specimens of it in every number of his publication, the majority of which are calculated to diffuse exceedingly bad taste among the public,—the editor of the *Art-Journal* appears anxious to get architecture thrust out of the Royal Academy. Some short time ago, he protested against architects being elected members of that body; and he now tells us that architectural drawings have "no business" to be in its exhibitions. This is very much like saying that there ought to be no exhibitions anywhere of such productions—the Academy's being the only one where they are admitted. It is to be hoped, however, that this marked insult will now arouse architects, more especially the leaders in the profession, and those who are members of the Academy, to a sense of their duty, and of what they owe, if not to themselves personally, at least to their brethren. Should it not do so, they must be lethargic indeed; and will fully justify at least one-half of the *Art-Journal's* opinion, by showing that at all events *they* have "no business" in the Academy.

What is the Professor of Architecture about, that he can patiently put up with the present state of matters with regard to architecture at the Academy? Hardly can he be ignorant of it, or not perceive how greatly it calls for correction; nevertheless, he makes no effort at all to correct it. Had he bestirred himself at all, we should of course have heard of it; moreover, if he had, and had done so ineffectually, we should have heard of his resignation,—which would be far more honourable to him than is the making himself a cypher,—not only without influence, but without even so much as a tongue or a voice.

Whatever—if any at all—the emoluments attached to the Professorship of Architecture may be, they cannot be such as to be of any moment to Mr. Cockerell. So long as the situation confers honour on him who holds it, it is worth having, whether any emolument at all be attached to it or not. But rather quite the reverse of honour attends it, when he who holds it is expected to sit by very tamely, and see all kinds of slights and affronts put upon architecture, without so much as attempting to check them.

There is, indeed, no danger of either the Professor or the Academy being called to account for the dereliction of their duty in regard to architecture, by the public press—that is, the newspapers; architecture being the very last thing of all to excite their attention or engage their sympathies. Yet if they, therefore, think that they are released from all responsibility to public opinion, and that their conduct excites no animadversion in other quarters, they are very much mistaken.

As to the editor of the *Art-Journal*, he ought to be hanged—in effigy, at least—by the architects. But, somehow or other, architects invariably show themselves to be the most pluckless race imaginable. Whenever their own personal interests are touched, or at all endangered, they are generally sensitive enough; but when it is only the credit of their art and their profession that is concerned, they show themselves to be the most torpid and sluggish of mortals.

Zero.

## THE DISPUTED INVENTION OF TUBULAR BRIDGES.

We regret to perceive, now success has attended the bold experiment of constructing tubular bridges, that attempts are being made to deprive Mr. Robert Stephenson of the merit so justly his due, as the original designer of the plan, and the superintender of its execution. Mr. Fairbairn, who, with Mr. Eaton Hodgkinson, assisted Mr. Stephenson in working out the design, claims to have the merit of all but the "original idea;" and he maintains that the working out of the idea and the development of the principle, as well as the greater portion of the construction, are the results of his labours. He states, also, that the original idea of Mr. Stephenson was a cylindrical tube, to be supported by chains; which plan, he says, can be proved would never have succeeded; and that it was only by a long series of inductive reasoning, founded on experimental research, of which he claims the exclusive merit, that the present strength and form of the Conway and Britannia tubular bridges were established.

It is of great importance not only to Mr. Stephenson, but to civil engineers and inventors in general, that these claims of Mr. Fairbairn should be estimated at their proper value. The original idea of overcoming the difficulty of taking the railway across the Menai Straits, by the construction of a tubular bridge, is admitted to be due exclusively to Mr. Stephenson. Mr. Fairbairn and Mr. Eaton Hodgkinson were employed by him to assist in its construction, and to make the experiments necessary to determine the best form for obtaining the requisite strength. He must, of course, have expected, from their known skill and experience in the strength of materials, that they would be able to afford important assistance in devising the means adapted to overcome the difficulties which such a novel structure necessarily presented. The experiments they made were subject to Mr. Stephenson's approval, and may be said to have been conducted under his superintendence. The mode of making them would however, for the most part, be necessarily entrusted to Mr. Fairbairn and Mr. Hodgkinson; who were not employed as mere mechanical agents, to act strictly under directions, but as practical men of science,—expected to bring their skill, ingenuity, and mathematical knowledge to bear on the important work entrusted to them, and to arrange the details by which Mr. Stephenson's invention could be best carried into effect. That Mr. Fairbairn has amply fulfilled what was expected from him, and has, under Mr. Stephenson's superintendence, completed the task ably, skilfully, and successfully, is a great merit, of which he may well be proud. Beyond this, he ought not to wish to carry his claims. Not only the original idea of tubular bridges, but a mode of carrying it into effect, unquestionably belong to Mr. Stephenson. Whether that was the best mode, was to be determined by experimental researches; and the result led to an improvement in the means first devised. This is the general and almost necessary course in the perfection of any invention; and whether the inventor carry on the experiments entirely by himself, or whether he obtain the assistance of others in perfecting his invention, does not affect his claim as the original inventor. It appears to us that a machinist or a draughtsman might, with nearly equal pretension, claim to be the inventor of an apparatus, or the architect of a building,—because he had succeeded in making the machinery, or in completing designs from outline plans,—as Mr. Fairbairn can claim to be the inventor of tubular bridges. We trust that, for the sake of his own reputation, he will be satisfied with the merit acknowledged to be his, and not persist in claiming more.

*Floating Tunnel across the Channel.*—One of the most extraordinary plans submitted for approval to the French Academy of Sciences is that of M. Ferdinand, engineer, who proposes to construct a floating tunnel from Calais to Dover, for the wires of the electric telegraph, and large enough to be traversed by small locomotives, for the conveyance of passengers. The plan was referred to one of the members of the Academy for examination.

## ON CHEMICAL AND ELECTRICAL FORCES.

By Professor Faraday.

Professor Faraday has this season delivered a course of seven lectures at the Royal Institution, "*On the Allied Phenomena of the Chemical and Electrical Forces.*" The last lecture of the course was given on Saturday, the 17th ult, and we now subjoin a brief sketch of the whole, showing the mode in which the subject was treated, and describing the principal experiments by which it was illustrated.

The *first lecture* was devoted entirely to explanations of the character and illustrations of the nature of chemical force, commencing with its simplest forms. In the first place, Professor Faraday explained the difference between mechanical force, or the force of gravitation, which produces molecular action and aggregation of masses, and the action of chemical force, which takes place among the particles of matter. At the same time as he entertains the opinion that all forces are closely allied, if not identical, he showed several experiments in which chemical action is effected by mechanical force, of which the explosion of fulminating powder by percussion afforded an example. The illustrations of chemical action in its feeblest form, he showed to be closely allied to mechanical force, as the aggregation of the particles of water, he said, depends on the same force as the most energetic chemical action; the difference between them being only in degree. As an illustration that chemical action takes place during the mixing of fluids, he poured some spirits of wine gently on to the top of water in a glass vessel, into which a long tube was inserted. The vessel and the tube being quite filled, he inverted the apparatus, to mix the spirits of wine with the water, when contraction in the volume of fluid was manifest by the tube being no longer full. Among other exemplifications of chemical action, were the solidification of two gases (muriatic acid gas and ammoniacal gas) on being mixed, and the conversion of two limpid liquids (carbonate of potass and muriate of lime) into a white solid mass. The results of chemical action, Professor Faraday observed, are the production of compounds distinct from, and frequently quite dissimilar to, the original substances that enter into combination. To show in a striking manner the difference between a mixture and a compound, he mixed together some copper and iron filings, and then separated the iron from the copper by means of a magnet; whereas in a chemical compound, no mechanical force can separate the combined particles, and they can only be resolved into their original elements by the chemical action of some more energetic agent. Though the original substances that enter into chemical combination seem to be entirely lost in the resulting compound, yet there is no destruction nor any alteration in the elements, nor is there any creation or destruction of power produced by the combination. Professor Faraday illustrated the reproduction of the elementary substance of a compound after it had been apparently destroyed, in the following manner. He put some iodine into a glass flask, which, on being heated, emitted the purple or violet-coloured fumes peculiar to that substance. He then added zinc and water to the iodine, when a combination took place, in which the properties of the iodine were apparently lost, and by no application of heat could the violet fumes be produced. On the addition of sulphuric acid, however, the iodine was set free from its combination with the zinc, and its fumes were again perceptible. That there is no destruction or change in the particles of matter produced by chemical action is generally admitted, but the Professor observed, that some philosophers still cling to the notion that there is a creation of power, as exhibited in electricity; but this opinion, he maintained, is not founded on fact, for there can be no creation of power without the creation of matter.

In the *second lecture* the consideration of the different actions of chemical force was resumed in the commencement, and then its gradual transition into electrical force was developed. In the first place, the Professor pointed out the difference that exists between the force of gravitation and chemical force in the relative constancy of their actions; for whilst gravitation never ceases to act at any moment, chemical affinity, on the contrary, often lies dormant for ages, until circumstances arise that bring it into action. Several experiments were performed to illustrate this, and also to show that the results of chemical action may be reversed by varying the temperature and the other conditions under which it takes place. A mixture of nitrous and oxygen gases, for example, produces no change on either litmus or turmeric paper, but when a stream of those mixed gases issues into the atmosphere at the ordinary temperature, a piece of moistened litmus paper exposed to the current is reddened, thus proving the presence of an acid. When the same stream of mixed gases is heated, the previously reddened litmus paper is restored to its original blue colour, and turmeric paper is turned brown, showing that the directly opposite property has been given to the gases, which then become alkaline instead of acid. When approaching to those chemical actions which are accompanied by the development of electricity, Professor Faraday first exhibited the solution of copper by an acid, and its reproduction in a metallic form on pieces of iron and zinc, which metals having a greater attraction for the acid that held the copper in solution than the copper itself, entered into combination with the acid and liberated the copper. He afterwards exhibited the action of oxygen and zinc, by first pouring some diluted sulphuric acid on a piece of that metal, which decomposed the water by attracting its oxygen, with which it entered into combination, and liberated the hydrogen as gas. On introducing a few shillings into the glass, the vigour of the action increased, and the decomposing power of the zinc seemed to be transferred to the silver, from which metal copious streams of hydrogen gas arose. A more obvious exhibition of the extension and transfer of chemical action from one metal to another was effected by the deposition of copper on silver from a solution of the sulphate of copper. When a piece of silver is immersed alone in a solution of sulphate of copper, no action whatever takes place, and it might so remain for any length of time without sensibly decomposing the solution; but as soon as a piece of zinc or iron is brought in contact with the silver in the solution, the copper is deposited on the silver as readily as on the zinc; and when the latter is amalgamated with quicksilver, the effects of decomposition are transferred entirely to the silver, and none of the copper is deposited on the amalgamated zinc. This effect is equally produced, whether the two metals are brought into contact in the solution, or whether connection between them is made by a wire, through which the action is readily transmitted. A new class of phenomena is brought into play by this exhibition of chemical force in dissimilar metals. When the wire that connects the two pieces of metal is made to pass over a suspended magnetic needle, the needle is deflected on one side, and by expanding the surfaces of the metals sufficient power is obtained to make a wire red hot. The deflection of the needle at any part of the connecting wire where it may be placed, shows that the action occurs along the whole course of the wire, and exemplifies one of the positions which the Professor wished to establish, viz., that the distant and local actions are identical. This new class of phenomena, Professor Faraday said, was, in his opinion, attributable merely to another exhibition of chemical force, but he should, in deference to received usage, denominate it electrical force.

The greater portion of the *third lecture* was occupied with the consideration of the decomposing power of electricity, in which respect its action seems the reverse of that of chemical force. The latter power acts by the affinities of the particles of one substance for those of another, and the results of its action are the formation of new compounds; electrical force, on the contrary, resolves compound bodies into their elements, and may act at a distance from its exciting cause. Numerous illustrations of the decomposing power of the voltaic battery were afforded, one of the most curious of which was the decomposition of muriatic acid by the following arrangement:—A glass vessel was divided into three compartments by diaphragms of blotting-paper, and filled with diluted muriatic acid,—the acid in the two end compartments being coloured with indigo. When the wires from the negative and positive poles of the battery were inserted in the two coloured divisions of the vessel, the muriatic acid became decomposed, the chlorine passing to one end, and the hydrogen to the other; which effect was rendered visible by the bleaching of the liquor in the end to which the chlorine was determined, whilst the middle compartment, through which the current force must have passed, remained unchanged. The decomposition of iodide of potassium afforded a striking example of the rapidity with which decomposition takes place under the influence of electricity. Across a piece of paper, wetted with a saturated solution of iodide of potassium, Professor Faraday drew rapidly one of the wires from the battery, when a strong brown mark was left, showing that the iodide had been decomposed. By pressing a coin on paper similarly prepared, and then touching it instantaneously with the wire of the battery, an impression of the coin was left on the paper, caused by the decomposition of the iodide where the parts most in relief had touched the paper. The amount of decomposition is, in all cases, proportionate to the current force; and though chemical decomposition does not take place excepting when the current is interrupted, yet the power is always active in its circuit through the connecting wires. The deflection of a magnetic needle, when placed parallel to the conducting wire, was adduced as a proof that the power exerts an influence at every part of the circuit, and the plates of the voltaic battery were shown to have the same power as the conducting wire, in deflecting the suspended needle from its ordinary position of north and south. This current of force throughout was noticed by Professor Faraday as one of the many instances in which electrical force differs in its action from chemical force, which is always local, though the two forces are really identical. The constant evolution of electricity, when we least suspect the presence of such an agent, was curiously exemplified by cutting a raw beef-steak with a steel knife and a silver fork, the knife and fork being connected by wires with a voltameter. As soon as the knife touched the meat, a current of electricity was evolved sufficient to deflect the needle of the voltameter. A cooked steak, peppered and salted, produced a still more powerful effect on the needle.

In the *fourth lecture* the alliance between the chemical and electrical forces exhibited in the evolution of light and heat, formed the principal point to which the Professor directed attention, and he illustrated the subject by numerous brilliant experiments. The light and heat produced by violent chemical action, of which a burning candle is a good example, form no essential part of the action that takes place among the combining particles, but are merely transient phenomena resulting from the activity of the combination. In the same manner, the light and heat evolved during combustion of substances by the voltaic battery, are the results of the combination of the zinc plate with the oxygen of the exciting liquid. To exhibit the voltaic light the lecture-room was darkened, and then pieces of charcoal were exposed to the action of the battery. The intensity of the light thus evolved was contrasted with the flame of an argand lamp, which was scarcely perceptible in the overpowering splendour of the voltaic spark. The combustion of silver-leaf, of iron-wire, of platinum, and of mercury, formed other dazzling exhibitions of the heat and light evolved by the voltaic battery, when the two poles were brought into contact with the

metals. The heat thus generated is owing, Professor Faraday observed, to the passage of electricity through the substances acted on, and to the resistance they offer to its passage, for when the conductors are sufficiently large and perfect to afford a free passage to the electricity, no effect of heat is observable. A very curious experiment in illustration of this property of electricity was exhibited. In a glass vessel full of distilled water the charcoal points from the opposite poles of the battery were introduced, and when they were brought near to each other a most brilliant light was evolved under the water, dimmed only by the bubbles of steam generated by the heat. The water being an imperfect conductor of electricity, offered sufficient resistance to its passage to bring into action the heating and light-giving powers of the voltaic battery; but when it was afterwards made a better conductor, by mixing sulphuric acid with it, the effect was greatly diminished. In the preceding lecture, Professor Faraday showed that wires proceeding from the opposite ends of a voltaic battery possess different powers in the decomposition of compound substances, and he now showed that their heating powers also differ; for the copper wires from the two poles, on being held close to each other within a short distance of the ends, the one became much hotter than the other. The quantity of heat evolved by the action of the voltaic battery is in proportion to the amount of zinc oxidized, and Professor Faraday remarked there is good ground for supposing that the heat evolved is equal to that produced by the combustion of the same weight of zinc. Though the intensity of the light varies in the phenomena of voltaic electricity, just as it varies in different circumstances during ordinary combustion, yet the heat remains the same in both cases. As an illustration of this position, the Professor directed his breath against a gas light so as to greatly diminish the brightness of the flame, yet in both circumstances, he said the heat of the burning gas was the same. The latter part of the lecture was occupied with the consideration of the effects of electricity on the sensitive system of animals, and it was illustrated by several curious experiments. The original experiment of Galvani with the hind legs of a frog was very successful; for when the legs were placed on a sheet of platinum, and connection was made between that metal and a piece of zinc that touched the nerves, the muscular contractions of the limbs made them jump as far as the animal could have done when alive. A large live eel, in a glass jar, plunged about violently when the electric current from the battery was passed through the water, thus showing, that without any direct connection with the battery, the electric shock is felt by fishes when the water they swim in is made part of the circuit. Professor Faraday alluded to the experiment made with the *gymnotus electricus* at the Polytechnic Institution, from which he had obtained all the effects of an ordinary voltaic battery. The eel itself does not feel the shock it communicates to the fishes within its influence, though when an electric current from a voltaic battery is passed through the water, it exhibits as much annoyance as any other fish. The Professor observed that the effects of electricity on the nerves of animals, give an insight into the phenomena of life, since they seem to prove that nervous irritability, on which the action of the muscles depend, is caused by electrical influence, though by what means the electricity is generated remains unknown.

The commencement of the *fifth lecture* was occupied with exhibition of the phenomena of electricity, when the circuit is not interrupted. The simplest evidence, that a constant action is going on in the conducting wire, is afforded by the deflection of a magnetic needle, when a wire that connects the two poles of a battery is held over it, parallel to the direction of the needle. Small pieces of bent iron, resting on the wire, became magnetic when the electric circuit was completed, and when the wire was twisted several times round a thick piece of iron, to increase the effect, the magnetic power became so strong, that it lifted an anvil of at least fifty pounds weight. The heating power of the voltaic battery, when the current is passing uninterruptedly along the wires, was shown by its making charcoal, and various thin wires red hot, in which state they would have remained as long as the battery continued in vigorous action. The conducting power of gold being greater than that of platinum, a fine wire of gold became a much brighter red by the passage of electricity through it, than one of platinum; and yet, when the two wires were joined together, the platinum wire became red hot, whilst the gold was not perceptibly heated. This anomaly Professor Faraday explained, by stating that the platinum wire obstructed the passage of the electricity, consequently the gold wire, which was capable of conducting a larger quantity, did not become sensibly affected by the small quantity which the platinum allowed to pass. The increase of heat diminishes the conducting power of metals, and several experiments were shown, for the purpose of illustrating this peculiar property, the red heat of one part of a fine communicating wire being brightened when another part of the wire was cooled; and the contrary effect being produced when the wire was heated by a spirit lamp. A great part of the lecture was occupied in explaining the two most popular theories respecting the nature of electricity, neither of which, however, Professor Faraday is inclined to adopt. One supposition is, that electricity is an ethereal imponderable body, distinct from the substances in which it is excited, and that it is transmitted along wires, in like manner to the rushing of fluids through tubes; the other, and as he observed, the more beautiful theory, is, that the phenomena of electricity are produced like sound, by vibrations. The Professor performed several experiments, for the purpose of showing the facts adduced in support of each of these theories. One of the difficulties to be overcome in any theory that purports to explain the nature of electricity, is to account for the instantaneous transmission of the power, which has been ascertained to exceed the rate of five thousand miles in a second. In support of the first theory, it is urged that as there is an immense difference in the rapidity with which different fluids pass along tubes—water, for example, flowing slowly in comparison with hydrogen gas—so it is asserted that the assumed imponderable fluid may pass with a rapidity vastly greater than hydrogen gas. The vibrations of sound, however, present much greater similarity to the transmission of electricity. Though sound passes in air at the rate of only thirteen miles a minute, it passes through water four times as quickly, and through glass sixteen times faster than through air. There is this resemblance also between the passage of sound and the transmission of electricity, that sound may be transmitted sensibly through solid bodies and become audible at the end. Two curious experiments were performed to illustrate this property of sound. A thin strip of deal was suspended from one end of the lecture-room to the other, and at the farther end it bore against a box. A tuning-fork, when struck and applied to one end of the strip of wood, caused the box at the other extremity to emit a loud musical sound, though the tuning-fork itself could scarcely be heard. In the other experiment a rod of metal passed through the floor of the lecture-room, and was placed in connection with a pianoforte in a room beneath. When the instrument was played, scarcely any sound was heard, until a guitar-case was placed on the rod, and then the notes were distinct and loud, as if proceeding from the guitar-case. There is a similarity also between vibrations and electrical shocks, as may be proved by striking a bar of iron when holding it near one of the points of vibration, the jarring sensation bearing a close resemblance to an electric shock. This vibratory sensation is felt yet more strongly when a wet string is fastened round the waist, and some one pulls the end of it through the fingers.

In commencing his *sixth lecture*, Professor Faraday said he was about to direct the attention of his auditors to a different condition of the electric force from that in which he had hitherto considered it, wherein the phenomena not only differ from, but are in many respects directly opposed to, those exhibited by chemical action and voltaic electricity; and yet the forces are the same. In the first place, he exhibited voltaic electricity in a higher state of tension than he had before done, by employing a water-battery, consisting of a great number of pairs of plates, by which arrangement a small quantity of electricity in a high state of concentration was excited. In this condition voltaic electricity nearly resembles the electricity excited by rubbing a stick of sealing-wax or a rod of glass. In the ordinary development of voltaic electricity, the effect is produced only when the current is passing, and ceases when it is broken; but in frictional electricity the power may be exerted when there is no current, and when the source of power is withdrawn. In this respect, indeed, the water-battery evolves electricity resembling that of the electrical machine, and forms the connecting link between frictional and chemically-excited electricity, serving to prove that they are identical. In the first place, Professor Faraday showed that by touching an electroscope with only one of the wires of the battery, the gold leaves diverged, and continued divergent when the wire was removed, thus exhibiting the development and the retention of the power when there was no current passing. When the wire from the opposite pole of the water-battery was brought in contact with the electroscope, the gold leaves collapsed. To show the identity of the electricity thus evolved by the battery with the electricity excited by friction, Professor Faraday caused the gold leaves of the electroscope, when diverged by the battery, to be collapsed when an excited rod of glass was brought near, and to be made more divergent by an excited rod of gutta percha, or by a rod of shellac. The different means by which the effect is produced affords no ground for supposing the electricity of the battery and that excited by friction to be distinct, for what is termed frictional electricity may be excited in varieties of ways, and is, in fact, continually being called into action, without our being sensible of its presence. The mere act of dusting a piece of metal with flannel was shown to excite electricity by its causing the leaves of the electroscope to diverge. We can scarcely touch anything without exciting this power, which, however minute and imperceptible in its development in these instances, is precisely the same force which produces the grandest phenomena of nature—thunder and lightning. Having given illustrations of the similarity of the forces developed by chemical agency and by friction, the Professor dwelt on the apparent differences between them. One remarkable difference is, that the substances by which frictional electricity is excited undergo no change, the metals and the glass remaining just the same after having developed the power as before; whereas voltaic electricity cannot be excited without chemical action, and an apparent destruction of the zinc. Another variation in the phenomena of voltaic and of frictional electricity is exhibited in their conduction through various substances. Water, for instance, which is so imperfect a conductor of voltaic electricity, will readily conduct the whole quantity excited by a powerful electrical machine, through the moisture contained in a wetted silk thread. Frictional electricity is spread over the surfaces of bodies, and does not enter them. This property was exhibited by several experiments, the most remarkable of which were the following:—A small metal ice-pail was placed on an insulated stand, and then a metal ball, suspended by a silk string, and charged with electricity, was lowered into the pail. The electricity instantly diffused itself on the outside of the ice-pail, and there was none within; for when the ball was again lowered into the pail and withdrawn, it produced no effect on the electroscope, but when the ball touched the outside the instrument was strongly affected. In the other experiment a wire-gauze vase was substituted for the ice-pail, with exactly similar results. When an electrical machine is excited, every

person within sight of it is more or less affected by its influence, and a condition of electricty is induced in that part of their bodies towards the machine of a different kind from that developed by the conductor; and on the opposite side, or that farthest from the machine, electricity of the contrary kind is induced. This induction of positive and negative electricity on distant bodies, leads, as Professor Faraday observed, to important practical consequences. He had, he said, been often consulted by Government as to the propriety of having metal roofs on the powder-mills at Waltham Abbey, and he had always objected to them as dangerous, because a thunder-cloud might induce in the extended metal surface, an amount of electricity capable of discharging itself to the earth. In illustration of this, a large insulated metal ball, placed at a distance of two feet from the conductor of the machine, was brought near a jet of gas, which became ignited by the induced electricity passing off in a spark to the metal gas-pipe, though the ball was far too distant from the conductor for any spark to pass between them. This experiment was repeated several times, and each time with the same success.

The chief point to which Professor Faraday directed attention in the *seventh* and concluding lecture was, the cause of the difference between the phenomena of voltaic and of frictional elecricity, his object being to prove that they are really identical. The marked difference between frictional and voltaic electricity, which were dwelt upon so much in the preceding lecture, are caused entirely by the different degrees of intensity in which the force is developed, and Professor Faraday showed, in the concluding lecture, that, by diminishing the intensity of frictional electricity, the phenomena may be rendered similar; the great difficulty in showing these effects being caused by the very small quantity of electricity that can be evolved in a given time even by the most powerful electrical machine when compared with the amount evolved by the voltaic battery. Though the machine employed was a plate of glass, about four feet in diameter, which yielded a rapid succession of strong sparks five inches long, it would require about five million turns of the plate to produce a quantity of electricity equal to that evolved by a grain of water in the voltaic battery. The different appearances of the sparks emitted in the highest state of intensity by the electrical machine from those produced by the discharge of electricity accumulated in the Leyden jar, and the alterations the light and the length of the sparks may undergo by being transmitted through various media, were shown in numerous experiments. Though the rapidity of the electric spark is evidently very great, it far exceeds, in reality, the appearance to the eye, for the duration of the impression on the retina after the light is extinct occasions a prolongation of the effect. It has been ascertained by Mr. Wheatstone, that the duration of the light of the spark is less than the millionth part of a second, and Professor Faraday exhibited the mode by which this fact had been established. A concave mirror, placed horizontally, was made to revolve with great rapidity by multiplying-wheels, and when in action a bright light from the combustion of lime was reflected to a focus on the ceiling. The rapidity of the motion caused the light to form a circle, in the same manner as the turning rapidly round of a lighted stick or of any other bright object seems to form a circle, in consequence of the impression on the retina remaining until the effect is renewed by the return of the light to its former place. When an electric spark was substituted for the permanent light, each spark was seen separately, and no circle or prolongation of the light was produced. The velocity of the mirror and the number of successive sparks being known, an approximation can be obtained to the duration of the light. It is in consequence of this instantaneous duration of electrical discharges that they fail to produce many of the effects of voltaic electricity, and if the continuous action of the latter during a second could be concentrated one million times its effects would be tremendous. By diminishing the intensity of frictional electricity whilst retaining its quantity, Professor Faraday ignited gunpowder, which was blown away without ignition by the undiluted discharge. The following experiment afforded a good illustration of the different actions of frictional and voltaic electricities caused by the concentration of force in the former. A gold thread twisted with silk was deflagrated by a discharge from an electrical battery without injuring the silk, the action having been so instantaneous that there was not time to burn the silk, though the metal was destroyed by the heat evolved. When similar gold thread was exposed to the action of the voltaic battery, the silk was instantly consumed by the wire being made red hot, whilst the metal remained. The statical character of frictional electricity, Professor Faraday said, may be rendered current by applying a conducting substance to draw it off from the machine as quickly as it is excited, and the imperceptible effects of such a current prove how small the quantity of electricity excited really is, and it is only by allowing it to accumulate that we become sensible of its presence. The phenomena of lightning and thunder are owing to the facility with which Franklinic electricity can be accumulated, and thus reserved in store for an instantaneous discharge. Some specimens of the effects of lightning were exhibited on the lecture-table. A number of splinters from a riven oak, a branch from a mulberry tree, the rent and shivered handle of a hay-fork, and the partially-melted iron cable of a ship were displayed. The latter is such an extraordinary exhibition of electrical power, that Professor Faraday said nothing but the strongest evidence could have induced him to believe it; the ship was stated to have been struck with lightning during an earthquake at Callao. This rending power of frictional electricity cannot be imitated by the voltaic battery, but all other phenomena of the one kind can be produced by the other. The decomposition of chemical compounds by the discharge of the Leyden jar was shown by the decomposition of iodide of potassium, small indeed in effect, but corresponding with the quantity of electricity which the electrical machine evolves. The alliance of the phenomena of the two electricities had been shown in the course of these lectures, Professor Faraday observed, by their physical effects in communicating shocks, by the equal rapidity of their transmission, by their decomposing and heating powers, and by the communication of magnetism. The difference between the two consists solely in the degree of intensity, the electricity of the machine exciting a small quantity in a high state of intensity, whilst the voltaic battery evolves a much larger quantity in a low state of tension. Professor Faraday, taking a small flock of gun-cotton and exploding it in the flame of a candle, observed that the chemical force thus instantaneously called into action was equal to the production of an amount of electricity greater than would be contained in 500,000 charges of the powerful battery of Leyden jars which he had employed to deflagrate metal wires and gold leaf; and the important problem now remaining to be solved was, the conversion of such rapid chemical actions into current forces. Chemical decomposition, he said, when taking place less energetically, had been shown to evolve electricity, which became manifest and available as a current force by the voltaic battery, and it was quite within the reach of scientific discovery to render the most energetic phenomena of chemical force sources of continuous power.

## PROCEEDINGS OF SCIENTIFIC SOCIETIES.

### ROYAL INSTITUTE OF BRITISH ARCHITECTS.

*May* 29.—Ambrose Poynter, Esq., V.P., in the Chair.

A paper was read "*On the Application of Sculpture and Sculptured Ornament to Architecture.*" By H. B. Garling, Associate. Being the Essay to which the Medal of the Institute was awarded on 21st February, 1848; and which is given in full in our present Number (p. 201).

*June* 12.—Sidney Smyrke, Esq., V.P., in the Chair.

A paper was read "*On the Theatres and Porticoes of Ancient Rome.*" By the Rev. Richard Burgess, B.D.

*June* 26.—A paper was read "*On the Triforium of the Mediæval Churches.*" By the Rev. R. Willis, M.A.

This evening's meeting closed the session.

Next month we will endeavour to give an abstract of both the above papers.

### INSTITUTION OF CIVIL ENGINEERS.

*May* 30.—Mr. Field, the President's Conversazione.

The accustomed annual conversazione of the President, which was heretofore held at the residence of the President, was this year held at the House of the Institution in Great George-street, a change we do not approve of; as also the one limiting the conversazione to one evening, which led to the rooms being most inconveniently crowded—so much so, that many of the numerous models and works of art could not be seen.

On the walls of the theatre we observed three faithful portraits, by Lucas, of Mr. George Stephenson, Mr. Robert Stephenson, M.P., and Mr. Bidder; they were contributed by Messrs. Graves, for whom they are about being engraved. The Electric Telegraph Company—Mr. Bain, Mr. Brett, and Mr. Reid—contributed instruments exhibiting their various systems of telegraphic communication, electric clocks, and electric printing. Mr. Rand's fly press, for raising at one blow the collapsible tubes or capsules. Mr. Whitworth's beautiful machine for knitting stockings was worked by a young girl sent up from the factory of Messrs. Ransome and May, of Ipswich, and formed an attractive object. The models of greater interest were those of Mr. Stephenson's wrought-iron tubular bridge erected at Conway; with that of his wrought-iron tubular girders for large spans. Mr. Fowler's steamboat floating landing stage, with its long approach over the mud banks, all to be supported upon Mitchell's screw piles, for the Humber Ferry. Mr. Brunel's excellent truss, of 110 feet span, used by him in the Somerset Bridge, on the Bristol and Exeter Railway. Mr. Fowler's plan for opening or shutting simultaneously four gates for a level crossing on the line of the Manchester, Sheffield, and Lincolnshire Railway. Messrs. Taylor, Williams, and Jordan's model of their machine for carving by machinery ornamental objects, figures or groups, such as we have previously noticed. This machine, by means of a tracer which guides the cutting tools, is enabled to perform the most delicate and elaborate work with great speed and at a cheap rate. Messrs. Seaward and Capel contributed a large collection of models of paddle-wheels and screw-propellers. Messrs. Maudslay and Field also contributed an interesting series of models of steam-engines, screw-propellers, and paddle-wheels; as did also Mr. Penn, of his horizontal trunk steam-engine. Mr. Clarke exhibited a beautiful model of the *Great Britain* steamer, full-rigged, and containing *fac-similes* of the engines, with the screw-propeller complete, and working by means of condensed air, the whole only weighing 1 oz.

Among the remaining models, we observed Messrs. Blake and Varley's atmospheric pile-driving machine,—Mr. Varley's rotating air-pump,—Mr. S. P. Bidder's simple and effective coal-drops,—Mr. Dodd's rail-straightening machine,—Mr. Southam's wedge and screw fix,—Mr. Thornton's improved hydraulic lifting-jack,—Mr. Wetherall's iron-twister,—Mr. Chrime's patent fire-plug valve,—Mr. Beattie's new wooden railway, with the drawing of the system of manufacturing it,—a model of a folding boat, of which each side was made of two thicknesses of water-proof cloth, filled in on Capt. Light's principle with very buoyant reeds, rendered non-absorbent, and consequently rendering the boat incapable of sinking, even when full of water, and even when partially torn by accident. The expedition in search of Sir John Franklin has been furnished with boats of this description, in order that they may be easily transported across the ice, and may bear injuries which would destroy a wooden boat. The Gutta-Percha Company sent a selection of their products from the rough material throughout all its stages of manufacture to the finished articles. Mr. Chubb's safety chest and locks and keys,—Mr. De la Fon's ingenious locks and bolts,—Mr. Defrie's improved dry gas-meter,—the new Aneroid barometers,—and numerous other interesting models and specimens.

*June* 20.—JOSHUA FIELD, Esq., President, in the Chair.

"*On Harbours of Refuge.*" By the Right Hon. the EARL of LOVELACE.

The paper consisted chiefly in a succinct review of the Reports of the Commissioners on Shipwrecks and on Harbours of Refuge; giving the opinions of the naval officers and civil engineers on the necessity for harbours, in certain situations, and the naval qualities possessed by those positions—the possibility of constructing harbours in them, and the nature of the structures. The necessity for harbours on our coasts, capable of sheltering fleets from storms in peace, and the enemy during war, appeared to be admitted, particularly at the present moment, when the disturbed state of the continent and the restless character of our near neighbours were considered. It was stated, that, of various situations pointed out, that of Dover was the only one yet decided upon, although great works are contemplated at Portland, where, from Mr. Rendel's designs, a system of construction would be adopted, which would be both economical and stable, and, at the same time, would afford employment to a class of persons whose labour it had been difficult hitherto to use efficiently. The various projects of floating breakwaters, and other artificial shelter for vessels, were then examined, and were generally condemned, as entirely inefficient for the objects proposed.

The questions relative to the movement of sand, the drifting of the shingle, and the deposit of silt in Dover Bay, and other places, were treated at great length, and reasons given for the various forms of construction, and of the projects for meeting the difficulties induced by these circumstances.

The next question was the place of the harbour, and the mode of construction of the works. After quoting all the authorities on both sides, including the naval officers, the commissioners, the civil engineers, and the scientific writers, the preference was given to a large harbour, with two entrances, so placed as to allow a sufficient run of the tide through it, to prevent any very considerable deposit of silt, but so constructed as to afford shelter to the vessels within. The pier walls inclosing the harbour to be built vertically up from the bottom, or with a very slight inclination in their height, instead of throwing in masses of rubble stone, to find its own angle of repose, which, it was shown, was not less than four or five to one, and that it only attained solidity after a lapse of many years, even with a due admixture of small materials to fill up the interstices, and after constant supplies of stone, to replace that which the seas had removed. The reports of Capt. Washington were quoted, to prove the failures that had occurred at certain harbours in Ireland, where it was stated that the long slopes had been destroyed by the sea, and had ruined the harbours they were intended to protect. The proceedings at Cherbourg and Plymouth were followed in great detail, with a view to deducing arguments against the long slopes, and in favour of vertical sea-walls.

The protest, by Sir Howard Douglas, in favour of long slopes, was examined at great length, and the arguments used on both sides were analysed with skill and candour.

Colonel Emy's theory of the effects of the "*float du fond*," was carefully examined; and, without going to the entire length that he did, it was admitted, in many cases, the effects produced were as he described them, and that the subject, as he had brought it forward, was well worthy the attention of civil engineers.

The placing a vertical wall upon a substratum of rubble, in the form of a long slope, was shown to be pregnant with mischief, and had never been successful; and that the adoption of that system at Cherbourg had been a matter of necessity rather than of choice.

Mr. Alan Stevenson's clever experiments, on the force of waves striking opposing bodies, were given; and it was urged, that the force shown to be developed by a breaking wave could not act upon a vertical wall, up and down which it would merely oscillate; whereas it might fall, with all its accumulated force upon a slope, upon which it would naturally break. In conclusion, it was urged that, although for Dover, which was the spot whereon to mount guard over the channel, in order not only to prevent invasion, but to maintain our present naval supremacy, it might be permitted to expend a large sum of money; yet it would not do *to have several Dovers*; and, therefore, it behoved the authorities to consider carefully the site, the plan, and the method of construction, before commencing works, in which, in the present state of engineering science, the experience of the past should be used to avoid the errors that had occurred in former and similar works.

In the discussion which ensued, and in which the principal civil engineers engaged on great hydraulic works took part, after justly complimenting the Earl of Lovelace, for the very able and impartial analysis he had made of the evidence contained in the Government reports, and the documents in his possession, the speakers explained most satisfactorily the actual circumstances and conditions of the works which had been instanced as failures; and it was shown, that far from being expensive or useless works, they had been completed within the original estimates; and that wherever the construction had required restoration, or addition, it had arisen from the use of defective materials, which, being on the spot, it had been obligatory to employ, and not from the use of the long slope, which, as compared to vertical walls in similar situations, was shown to be more durable, and to have been, in many instances, successfully substituted for vertical walls, after they had succumbed to the assaults of the raging billows.

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## INSTITUTION OF MECHANICAL ENGINEERS.

*June* 13.—J. E. M'CONNELL, V.P., in the Chair.

### ON THE BALANCING OF WHEELS.

Mr. M'CONNELL read the following interesting paper on the above subject:—The paper treated on the balancing of wheels as a very important matter, as most of the accidents from carriages jumping off the line, had arisen from the balance in the wheels of the engine. The first who made this matter of practical observation was Mr. George Heaton, of Birmingham, on examining a lathe in the turning-rooms of Earl Craven, the pulley of which he found to be out of balance. This he remedied, and the lathe worked well again. Mr. M'Connell instanced several railway accidents of late, which had arisen from a want of proper balance in the wheels of the engine. He then proceeded to illustrate the usual method of balancing the wheels of locomotive engines, which he considered an improper one, and, on reference to experiments with another model, pointed out the desirability of obtaining an accurate balance in the piston and piston-rod.

In the course of the paper, Mr. M'Connell exhibited various experiments with a model railway carriage, explanatory and illustrative of the statements advanced in the above paper. The first experiment was made with wheels in balance, the motion to which was given by a spring, and the sustained regularity of the motion was unexceptionable. In the second experiment, a small piece of iron was inserted in the wheels, and the balance consequently destroyed—the natural tendency being to cause a jumping and jerking motion, to obviate which was the object sought in this contrivance. Similar experiments were made, to show the necessity of adopting a similar system of balancing the piston and piston-rods, in order to obviate this same jumping motion.

In explanation, Mr. M'Connell said, that the wheels could be properly balanced together. First, one wheel was balanced, and then they put the other wheel on upon the other side of the engine, and balanced it in the same manner. When the matter was first placed before Mr. Robert Stephenson, that gentleman considered it of no service, and it met with much opposition; but since that time Mr. Stephenson, and many other gentlemen, had adopted a plan of balancing their wheels, which, in his (Mr. M'Connell's) opinion, was not the correct one. When a locomotive-engine was connected, and the driving-wheels and working part attached, it was lifted up upon centres, and set slowly in motion, balance-weights being added until it moved at a certain speed without oscillating, and it became perfectly settled on its centres. That plan might answer tolerably well, but it was the really true mode of balancing wheels. He considered that great evil resulted from the piston and piston-rod not being in balance; it had been the cause of accidents in several cases where the engine did not leave the rails when the wheels were in balance. If the engine attained a certain velocity—the piston-rod moving 1,000 feet a minute—this momentum became so great, that the engine must jump; and the front wheels were, in some instances, clear of the road, and they could see between the wheel and the rail. They had an engine at Wolverton, fitted up with those correcting-weights, and it had been tried, for the first time, that morning on blocks. The engine at a certain speed on the blocks, threw itself down, and they were not able to run it so fast as might be wished; but, on attaching the balance-weight, the motion of the engine was completely neutralised.

Mr. MIDDLETON said, that this appeared to be the system of balancing wheels, which had been introduced to the notice of the North-Western Railway, some years ago, by Mr. George Heaton, and against which hitherto there had been much prejudice. He felt convinced that it was one of the best methods ever suggested for securing the safety of the public, when travelling on railways, and a great many accidents might be obviated by the adoption of this, or some similar plan of balancing the wheels of engines and carriages. It was supposed that the North-Western line had disapproved of Mr. Heaton's plan, but he was happy to find that there was now some probability of Mr. Heaton reaping the reward of his industry by the use of his patent.

Mr. COWPER said, that a system of balancing wheels was used by the

Eastern Counties Company eleven years ago; but this was decidedly a superior plan to any he had ever witnessed, and in many respects superior to the plan he had seen of Mr. Heaton's.

Mr. M'Connell said, that Mr. Robert Stephenson had expressed his entire approval of the utility of the proposed mode of balancing wheels, and had already given orders for it to be attached to an engine he was now constructing.

## LIGHT ENGINES—LIGHT TRAINS.*

The Secretary read the following paper on the above subject, by Mr. Samuel, engineer of the Eastern Counties Railway:—"The small locomotive, lately introduced on the Eastern Counties Railway, having attracted some considerable attention, has induced me to present to your notice a short description of it; and, at the same time, to offer a few observations on the practicability of the principle to the conveyance of passengers. This carriage was constructed under my superintendence, for the purpose of conveying myself and inspectors on the lines of the Eastern Counties Railway, and thereby avoiding the great expense of special engines. The total length of the carriage is 12 ft. 6 in., and includes machinery, water-tank, and seats for seven passengers, on one frame, which is hung below the axles, and is carried on four wheels, of 3 ft. 4 in. in diameter, the floor being within nine inches of the level of the rails. It is propelled by two cylinders, 3½ inches in diameter, with a 6-inch stroke, placed on each side of the boiler, and acting on a crank axle. The boiler is cylindrical, placed vertically, and is 1 ft. 7 in. in diameter, by 4 ft. 3 in. in height; containing a fire-box, 16 inches diameter, by 14 inches high; and 35 tubes, 3 ft. 6 in. long, by 1½ inches diameter: giving 5½ feet heating surface on the fire-box, and 38 feet on the tubes. The engine is fitted complete, with link-motion, feed-pumps, &c. The water-tank is placed under the seats, and will contain 40 gallons. This carriage is capable of conveying seven persons, at the rate of 30 miles an hour. It has, at times, attained a speed of 44 miles. The consumption of coke is only 2½ lb. per mile; and the weight of the whole machine does not exceed 25 cwt., including coke and water. The result of observations, which I have for a considerable time been making, on the Branch Passenger Traffic of Railways, has been to convince me that, on the whole, it is not remunerative, and, in some cases, is even worked at a loss. I have been, therefore, led to consider whether the expenses might not be reduced, by the introduction of a system of steam-carriages more suitable to the amount of traffic to be conveyed. It is evident, that the more we can reduce the dead weight of the trains and engines, in proportion to the number of passengers, the less will be the expense of repairs, both of the carrying stock and engines, and of the way and works of the line. The average weight of a train, on the branch lines of the leading railways, is 56 tons; the number of passengers, conveyed by each train, not exceeding 35 to 40 on many of the branch railways in England. Supposing each passenger, with luggage, to weigh 1½ cwt., the total weight of passengers conveyed is about 3 tons; or, in other words, for every ton of paying load we are now carrying by the present system of locomotion, we have from 18 to 20 tons of dead weight. It is, therefore, in a commercial point of view, of the greatest importance, not only to railway companies, but to the public generally, that some less expensive, and, at the same time, equally safe, means of transit be adopted. It is, therefore, proposed to substitute steam-carriages for locomotives on branch railways, similar in construction to the drawings herewith produced. These drawings represent a patent steam-carriage, now in course of construction, under my direction, by Mr. W. B. Adams, the patentee, for the Eastern Counties Railway Company. The following are a few of the principal dimensions:—Diameter of cylinders, 7 inches; length of stroke, 12 inches; diameter of driving-wheels, 5 feet; distance between centres, 20 feet; width of framing, 8 ft. 6 in. The boiler is of the ordinary locomotive construction; 5 feet long, by 2 ft. 6 in. in diameter. The fire-box is 2 ft. 10½ in. by 2 ft. 6 in. There are to be 115 tubes, of 1½ inch in diameter, and 5 ft. 3 in. in length, giving 210 feet of heating surface in the tubes. The area of the fire-box is 25 square feet, giving a total of 235 feet of heating surface on the boiler. The consumption of coke I have estimated at 7 lb. per mile, at a velocity of 40 miles per hour. The total weight of the steam-carriage, with its coke and water, will not exceed 10 tons, and it will be capable of conveying about 42 passengers, at a speed of 40 miles per hour. The water is to be carried below the floor of the carriage, in wrought-iron tubes, of 12 inches diameter, and 12 feet long. One great object attained in this machine, is the reduction of the centre of gravity, and the consequent absence of lateral oscillation. This carriage is intended for the Enfield and Edmonton branch of the Eastern Counties Railway, and is expected to be at work in about three months from this date. When its practical utility and economy has been proved, I shall be glad to submit the result to the Institution at a future meeting; as I feel convinced that the subject is one deserving the attention of the members, and of all parties interested in the profitable working of railways. I may also add, that were the system of light steam-carriages adopted, branch railways might be constructed at a very small cost indeed, compared with the present outlay (which is unavoidable so long as the present system of heavy engines is continued); and the advantages of railway accommodation might be extended to those districts, which can never hope to enjoy them, if the construction of railways continue to require such large outlay of capital."

Mr. M'Connell also read a communication on the same subject. He had declined giving any opinion, wishing to take the sense of the Institution upon the merits of the engine in question.

Mr. Samuel considered that his engine would save a considerable sum in the wear and tear of the rails, if not in coke, in consequence of the great reduction in the weight of the engine. He estimated the wear and tear of rails at £80 per annum, independent of the loss in the tyres of driving-wheels, which was a large source of outlay. He suggested the running of a number of small trains on a light description of rails, which would reduce the cost of branch railways, and, at the same time, be adequate to all the local traffic.

A Member inquired, how the projector would be enabled to convey heavy castings upon such a line?

Mr. Samuel said, that might be obviated by distributing the weight over several trucks, as was sometimes found necessary upon the lines now in use; and, in case of holiday excursions, he proposed running a number of these small trains, instead of the present heavy ones.

Mr. M'Connell said, that he presumed it would be desirable to have the rails sufficiently heavy to allow an ordinary locomotive to travel over them, in case additional carriages had to be taken on at certain points of the line, for extra traffic arising from holidays, races, &c.

Mr. Samuel said, it would be desirable that such should be the case, where it could be done. It was proposed to construct these rails on longitudinal bearings of timber—therefore, a comparatively heavy engine might traverse it without danger. In reply to further questions, Mr. Samuel said, that the pressure usually used in this engine was 120 lb.; but it was not proposed to work those branch engines at a pressure of more than 80 lb.

Mr. M'Connell and Mr. Cowper considered this engine peculiarly calculated to be worked with economy on the branch lines, as it would tend very much to make them pay, by economising the locomotive expenditure.

Mr. Buckle inquired, how the distance of the wheels would suit the present turn-tables?

Mr. Samuel said, it was usual, at every terminus, to have a large turn-table, suited for engine and tender; and, where there was not such a contrivance, they could make a triangle, which would be as good. The increased speed obtained on these trains would obviate the necessity of frequent changes of carriages; and he estimated the average cost of conveying the passengers would not exceed one-fifth of a penny per mile. Many of the branch lines did not pay, and some economising principle was needed to effect that object. In answer to further questions Mr. Samuel said, that he proposed to work the goods traffic in a similar manner.

Mr. M'Connell still thought that the rails should be equal on these branch lines, to bear the ordinary engines now in use on the main lines, in case they went over them; the wear and tear would also be less upon strong rails.

Mr. Cowper considered the ordinary rails in use were much too light, and, at the present price of iron, he thought it bad policy to lay down a light rail.

The meeting expressed their entire approval of the engine for all the purposes of the ordinary branch lines of railway.

* This paper fully supports our remarks in the "Journal" for December last (vol. ix., p. 385.)

## NOTES OF THE MONTH.

*Daguerreotype Plates.*—The plates prepared by depositing silver by electrical agency have been found far superior to the ordinarily-prepared plates. The mode adopted by Mr. Kilburn to test the superiority of the electro-plated metal is to deposit silver, by a Smee's battery, on one-half of a regularly-prepared plate, and then to apply the sensitive coating, and to go through the usual process of taking a picture. He says that the lights and shadows on the half that has been electro-plated will be much more clear and distinct, and that in comparison with that portion of the plate, the other will appear greasy. The requisite time of exposure also is found to be reduced about one-third.

*Aerial Navigation.*—Mr. Pitter, of Launton, Oxfordshire, has published plans and descriptions of an "improved Archimedian Balloon," whereby it is proposed to move through the air by paddle-wheels, set in motion by a steam-engine. This aerostatic machine will indeed be a "monster balloon," as it is proposed to give it buoyancy sufficient to raise thirteen tons; and it is to be 120 feet long, exclusive of hemispherical ends. Mr. Pitter conceives there will be little difficulty in steering this aerial ship, but he seems altogether to overlook the absence of a guiding resistance, for though he may be able to turn the machine round, that would be of no avail in steering, unless there be some resisting force superior to that of the wind.

*Railways Opened.*—One of the lines of rails of the Bolton, Blackburn, and West Yorkshire has been opened. The Tiverton branch of the Bristol and Exeter line was opened on the 12th June.

*Compromise of the Gauge Question.*—It has been decided by a committee of the House of Commons, "that the double gauge shall be laid down

from Fenny Compton to Wolverhampton, the mode of laying down to be such as the Railway Commissioners may approve." "By this decision," says the *Railway Chronicle*, "the settlement of the gauge question, to attain which a commission was appointed in 1845 and legislation took place in 1846, is sent to the wind."...."Thus, diversity of gauge is being allowed to take root in the most pernicious form which it could adopt—namely, the double gauge system."

*New Atmospheric Railway.*—A working model of Messrs. Harlow and Young's atmospheric railway has been recently exhibiting, and it works very satisfactorily on a length of 150 feet, with a four-inch tube. The peculiarity of the invention depends on the formation of the valve. The tube is cast with a longitudinal opening, similar to Clegg's; but, instead of a flap-valve, the action is precisely similar to the slide-valve of a steam-engine. The sides of the opening are so cast, that one side presents a horizontal groove, and the other a tabular face, both planed perfectly true. On the tabular face the slide-valve rests, when forced out of the groove by the passage of the coulter, consisting of bars of iron, in a full-size working tube, proposed to be 4 or 5 feet in length. At each end of these bars a semicircular opening is turned through about half their thickness, forming, when two abut against each other, a circular slot, in which is placed a disc of iron, ground perfectly true with the under surface of the bars, and thus presenting a sort of rule joint without any fixed axis, and forming collectively a loose chain which slides over the opening, and renders it air-tight. To each of these bars, or links, is placed a steel spring, in the shape of a carriage-spring, merely of sufficient power to press the valve into its place, after the passage of the coulter. The whole is covered by a top plate, to keep out grit, wet, snow, &c., with the exception of a small space to allow the coulter to pass, which is not much thicker than a saw blade, and which connects the leading carriage with the piston in the usual manner.

*Preservation of Wood for Railway Sleepers.*—Messrs. Hutin and Boutigny have obtained a patent in France, for the preservation of wood intended for railway sleepers; the process of which depends on filling the pores at each end with a bituminous cement, after the ends have been previously charred. The process is thus described: "Immerse the ends of a piece of wood in some liquid carburetted hydrogen, such, for instance, as the oil of schist, which penetrates quickly some distance into the wood. 2. Set this carburetted hydrogen on fire, and at the moment the flame has burnt out, plunge the wood to the height of a few inches into a hot mixture of pitch, tar, and shellac, which will be slightly drawn up between the fibres, and form at each extremity of the wood a kind of hermetical seal, unalterable by moisture and air. 3. Coat the wood with tar over its whole surface by the ordinary methods."—A process nearly similar was not long since communicated to the Paris Academy of Sciences, by M. Gemini, In his plan, tar is used for the purpose of filling the pores of the wood, without the addition of any substance. He encloses the wood in a cylinder, wherein it is dessicated by high-pressure steam. A vacuum is then produced, and additional force is given to the tar in its penetration of the fibres of the wood by a force-pump. M. Gemini observes that a separation takes place between the solid portion of the tar (the pitch) and the oily portion; and that the first penetrates only an inch, whilst the oily matter will penetrate throughout the whole substance of the wood.

*The "Divining Rod."*—It is a practice not uncommon in the mining districts of Cornwall, to search for veins of ore by the "divining rod," which is supposed to be attracted towards the metal on walking over the surface of the ground. The following letter, in the *Mining Journal*, signed "H. F. Penny, Notting-hill," thus describes the *modus operandi*, as having been successfully practised in his presence. If Mr. Penny be neither deceiving nor deceived, this is one of the things that philosophy cannot account for:—"I have witnessed the operation of the divining rod, in a manner most conclusive and satisfactory to my own mind. I went, accompanied by Mr. H., first to Wheal Jane, the underground captain of which is what they call a douser. He ordered one of the men to cut half-a-dozen withes, of the requisite shape, from a neighbouring hedge, and we then proceeded to a field, across which the lode lay. We each held a rod, and walked abreast, the captain in the middle. Upon crossing the lode his rod bent downwards, and, to my surprise and delight, I felt, at the same time, mine pressing against the flesh of the finger, when it went down gradually from being perpendicular to horizontal, but would not go lower. Mr. H.'s remained perfectly stationary! We tried it again and again with the same result—the captain's, however, going lower and more freely than mine. We then went to another mine beyond Perran, and sent for a labouring miner from underground, who is a celebrated douser. We had another gentleman, a Mr. C., with us, an old farmer, a clerk of this mine, and myself—thus making six, all armed with rods. On crossing the lode, the dowser's rod went down like a shot, completely inverted! Mine went down gradually, but its pressure was quite perceptible, until one of the limbs of the rod, close to my fist, actually broke off, from the mysterious force in operation. Now, holding my hands perfectly still, and grasping each limb of the rod, it is impossible to move it downwards by any voluntary motion, much less to break it. Mr. H.'s remained as usual, quite stationary, as also the clerk's; the farmer's and Mr. C.'s acted nearly as powerfully as mine, very much to the astonishment of the latter, who was an unbeliever. I may mention, that it will not act with one person out of 50, or, perhaps, out of 100."

*The Magnetic Telegraph.*—Mr. Nathaniel Holmes, who is in the employment of the Electric Telegraph Company, has made an improvement in the magnetic telegraph which promises to be of great utility. The invention is thus described by himself in a letter to the *Athenæum*:—"It may not be uninteresting to record the recent improvement I have made in reducing the expenditure of battery power to one-tenth of the amount required before; so that now, instead of working on the long circuit (a distance of about 250 miles), with an equivalent of 240 pairs of plates, 24 pairs do duty, with a much more effective result—the reduced intensity not suffering so much by the effect of bad insulation. The most important point, however, is the economy of power when it is applied to the numerous stations throughout the kingdom, and the increased facility of working through a much larger amount of circuit resistance. The addition consists in the substitution of a single small steel lozenge, three quarters of an inch long, for the two 5-inch astatic magnetic needles, and placed between two small coils, of peculiar shape. This form has the advantage, besides those already mentioned, of giving a signal free from that constant vibration of the needle, against which so much has been said—the pendulous action of gravity being very limited, from its better adapted form."

*Telegraph Profits.*—The profits of the New York and Washington Telegraph Company are reported to amount to 1,000 dollars per month. The Western Telegraph Company is, however, said to be doing a better business than that.

## LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM MAY 30, TO JUNE 16, 1848.

*Six Months allowed for Enrolment, unless otherwise expressed.*

William Wood, of Cranmer-place, Waterloo-road, Surrey, carpet manufacturer, for "Improvements in weaving carpets, and in printing carpets and other fabrics."—Sealed May 30.

William Seaton, of Camden Town, Middlesex, gentleman, for "Improvements in closing tubes, and in preventing and removing the incrustation in boilers."—May 30.

Jasper Wheeler Rogers, of Nottingham-street, Dublin, civil engineer, for "certain Improved methods and machinery for the preparation of peat as a fuel, and in combination with certain substances as a compost or manure."—June 1.

Richard Christopher Mansell, of Grange-road, Surrey, gentleman, for "certain Improvements in the construction of vehicles used on railways or on common roads."—June 1.

Thomas Hunt Barber, of King-street, Cheapside, for "Improvements in machinery for sawing wood." (A communication.)—June 1.

James Barsham, of Stratford, Essex, manufacturer, for "Improvements in the manufacture of mats."—June 1.

Thomas Burdett Turton, of Sheffield-street, manufacturer, for "certain Improvements in machinery for bending and fitting plates or bars of steel, iron, and other materials, to be used for locomotive engine and carriage springs, and other purposes."—June 1.

Henry Adcock, of Moorgate-street, London, civil engineer, for "certain Improvements in furnaces and fire-places."—June 3.

William Brindley, of Birmingham, manufacturer, for "Improvements in the manufacture of articles of papier-mache."—June 6.

Richard Barnes, of Wigan, Lancaster, gas engineer, for "certain Improved apparatus for manufacturing gas for illumination, part of which improvements is applicable to retorts for distilling, pyroligneous, and other similar purposes."—June 6.

Benjamin Lathrop, Esq., of King-street, Cheapside, London, for "an Improved wheel for railway purposes."—June 6.

Joseph Foot, of Spital-square, Middlesex, silk manufacturer, for "Improvements in making skeins of silk."—June 8.

Joshua Procter Westhead, of Manchester, manufacturer, for "Improvements in manufacturing fur into fabrics."—June 8.

Thomas Dalton, of Coventry, silk dyer, for "Improvements in the manufacture fringes, gimps, and bullions."—June 8.

Paul Marie Darlu, of Paris, in the Republic of France, for "Improvements in obtaining motive power."—June 8.

Richard Want and George Vernum, both of Enfield, Middlesex, engineers, for "an improved steam-engine, which may be also worked by air and other fluids."—June 10.

John Miller, of Henrietta-street, Covent Garden, gentleman, for "a new system of accelerated menatrite locomotion, even by animal impulsion, for every species of transport machines acting by means of wheels, whether on land or water." (A communication.)—June 13.

Charles Henry Capper, of Edgbaston, Warwick, gentleman, for a method of preparing and cleansing minerals and other substances."—June 13.

Joshua Taylor Beale, of East Greenwich, Kent, civil engineer, for "Improvements in the construction and arrangement of engines and machinery for propelling boats or vessels on water, with a means of preventing incrustation in the boilers, parts of which improvements are applicable to land purposes."—June 13.

William Hunt, of Dodder Hill, Worcester, chemist, for "Improved apparatus to be used in processes connected with the manufacture of certain metals and salts."—June 13.

Sir Henry Hart, Commissioner of Greenwich Hospital, Rear-Admiral in the Navy, for "Improvements in apparatus for preventing what are called 'smoky chimneys.'"—June 13.

William Chamberlin, jun., of St. Leonard's-on-the-Sea, Sussex, gentleman, for "Improvements in apparatus for recording votes at elections."—June 13.

James Roose, of Darlaston, Stafford, tube manufacturer, and William Haden Richardson the younger, of the same place, for "Improvements in the manufacture of tubing."—June 15.

George Emmott, of Oldham, in the county of Lancaster, civil engineer, for "certain Improvements in the manufacture of fuel, and in the construction and arrangement of furnaces, flues, boilers, ovens, and retorts, having for their object the economical application of caloric, the manufacture of gas for illumination, and the consumption of smoke and other gaseous products."—June 16.

## THE JACQUARD PUNCHING MACHINE.

*( With two Engravings, Plates X. and XI.* )*

*Patent Machine for Perforating Metal Plates, such as are used for Steam-Boilers, &c.; and employed for Punching the Plates of the Tubular Bridge at Conway; made at the Globe Works, Manchester, by* Messrs. Roberts, Fothergill, and Co.

Mr. Roberts, the patentee, has most liberally, at our particular request, furnished us with all the detailed drawings of this very important machine; for which we are sure all our mechanical readers will join with us in awarding thanks for his liberality.

Fig. 1 (Plate X.) represents a sectional elevation of the machine; fig. 2, an elevation of the back of the machine; fig. 3, a plan-view of the apparatus for putting the punches out of action without stopping the fly-wheel; and fig. 4, a plan-view of a few of the Jacquard plates. Fig. 5 (Plate XI.) represents a front elevation; fig. 6, a side elevation; and fig. 7, a horizontal section, taken through the dotted line $A^1$, $A^1$, in figs. 1 and 2. Fig. 8 is a detached view of the traverse-apparatus; and fig. 9, a detached view of the holding-down or stripping apparatus. A, A, the standards. B, the bed, through which there is an opening for the punchings, or metal punched out of the plate, to fall through; this bed is inserted into the standards. C, a stretcher-bar, to connect the top of the standards. D, fulcrum of the levers *q*, *q*, which withdraw the punches, and of the lever *w*, which traverses the plate. E, a fulcrum-shaft, to which the levers *j*, *j*, and *k*, *k*, are keyed. F, the main or eccentric shaft, working in bushes in the standards. G, a spur-wheel, keyed on the eccentric-shaft. H, a pinion, working into the wheel G. I, the fly-wheel shaft, on which are the fast and loose pulleys K, and L, the pinion H, and the fly-wheel J. M, M, connecting-rods, fitted to the eccentric necks of the shaft F. N, N, caps of the connecting-rods M, M. O, O, guide-plates for the punch-rams P, P. Q, the cam-shaft. R, a spur-wheel, loose on the cam-shaft, and having on one side two projections, between which there is an opening. R*, a locking-disc or plate, keyed on the shaft Q, having upon it a spring catch 38, which takes into the opening between the projections on the wheel R. R, and R*, are seen detached in fig. 5, and the dotted lines on R* represent a weight to counterbalance the levers *k*. S, a toothed-wheel, keyed on the main-shaft F. T, the punch-ram-depressor, secured to the connecting-rods M, M, by knuckle-joints at the lower end of the connecting-rods. U, a slide-bar, on which the frame traverses, which carries the plate to be punched. V, V, two short slide-bars, to carry one side of the traverse-frame. W, a block of iron, fastened with short wedges to the bed B, to carry the die-plate X, into which the dies *d*, are inserted, and prevented from rising by a collar at the lower end of each, as seen in fig. 11. Y, a square shaft, carrying the holding-down levers, or stripping-fingers, *o*, *o*. Z, Z, levers on each end of the shaft Y. *a*, *a*, the punches let into the punch-holders *b*, *b*, bolted to the rams P, as seen in the detached view, fig. 5. *c*, *c*, pieces bolted to the bed B, to carry the adjusting slide-bars V, V. *d*, dies inserted into the holder X. *e*, *e*, (fig 1), are the selecting slide-bars, which, when allowed to pass through the card-plate, enter the card-roller *f*, without being pushed backward by them; the card-roller has in this case six sides, and the belt of Jacquard plates, after passing over it in the usual manner, passes over a round roller suspended in a swing-frame, at such an angle as shall keep the belt moderately tight, whilst the roller *f* advances towards and recedes from the selectors *e*. *g*, *g*, brackets projecting from the depressor T, and carried up and down with it. *h*, *h*, sliding-blocks, in which the journals of the card-roller turn. To an upright cast on each of these blocks, is fitted a rod of round iron, thus, *, with a flat foot, long enough to extend over two of the six pins in the ends of the card-roller, against which the flat foot of the rods is made to press, by spiral-springs coiled around them in the usual manner employed in the Jacquard-loom, which is generally known, and need not be further described. *i*, *i*, (fig. 1), are two sets of guide-blocks, for the selectors *e*, one on each side of the depressor, adjustable laterally by set-screws on flat bars, extending across the machine; the use of these blocks is to carry the selecting-bars *e*, which are round at the end that enters the cards, and flat at the other end, to keep them in their proper positions; the centre portion of each selecting-bar is a solid piece of iron, projecting as much below the round stem as will, when the selecting-bar is driven backwards by a card-plate, permit the depressor T to complete its downward stroke without the selecting-bar touching the ram P, under it. *j*, *j*, are levers keyed on the shaft E, and connected at their lower end by links to the slide-blocks *h*, *h*. *k*, *k*, are levers also keyed on the shaft E, and having each a friction-roller at its lower extremity. On the shaft Q, are two cams, one of which works a lever *k*, on one side of the shaft, and the other cam works the other lever *k*, on the opposite side. One of the cams, through the medium of the levers *j*, *j*, and the links before referred to, causes the roller *f* to approach the selecting-bars *e*, and the other cam causes the roller to recede from them, until by a catch employed in the ordinary way in the Jacquard looms, the roller *f* is made to turn through one-sixth of a revolution, and is then retained in that position by the pressure of the spiral spring and flat foot above referred to. *l*, *l*, are brackets attached to the depressor T, at the back of the machine, seen best in fig. 1. *m*, a bar resting on the brackets *l*, *l*, and connected by rods with the sliding-blocks *h*, *h*, which, on receding, cause the bar *m* to bring all the selecting-bars *e* into the position for depressing the rams, as seen in fig. 11. *n*, *n*, are levers having their fulcra on studs screwed into the standards; one end of these levers is connected by a rod *p*, with the levers Z, Z; the other end is furnished with a roller which is acted upon by a cam *u*, on the shaft Q, (see fig 8). *o*, *o*, are the holding-down levers, adjustable laterally on the shaft Y, so as to admit of one of them being placed on each side of every punch. *p*, *p*, are rods connecting the levers *n*, and Z. By adjusting the length of these rods, the levers *o*, *o*, are made to press upon plates of different thicknesses, so as to hold the plates down while the punches are being withdrawn. *q*, *q*, levers turning on the fulcrum-bar D, for withdrawing the punches by means of the cams *r*, *r*, that actuate levers *q*, *q*. *s*, a broad but rather thin bar, extending through the series of punch-rams P, shown by dotted lines in figs. 7, and 2. The punch-rams P, are made with slots, through which the bar *s* passes, and these slots must be about two inches longer than the width of the bar *s*, in order to allow the punch-rams to be forced down when the bar is at the bottom of its stroke. *t*, *t*, are links connecting the bar *s* with the levers *q*, *q*. *u*, *u*, are cams which depress the holding-down levers *o*, *o*, through the medium of the levers *n*, *n*, rods *p*, *p*, and levers Z, Z, and hold down the plate while the punches are being withdrawn. *v*, a cam for the traversing-rack 5. *w*, a lever turning on the fulcrum-bar D, and worked by the cam *v*. *x*, the cam for lifting the rack 5. *y*, a lever turning on a stud in the standard, and worked by the cam *x*, for lifting the traversing-rack 5. *z*, a rod connecting the lever *y* with the lever 8, seen best in fig. 10. 1, is a lever on the traverse-shaft 2. 3, another lever on the shaft 2. 4, a link connecting the lever 3 with the rack 5. 6, a rod connecting the lever *w* with the lever 1, for traversing the rack 5. 7, a shaft for carrying the levers 8, 9, and 10. 11, a link connecting the levers 10 and 12. 13, a shaft carrying the levers 12 and 14. 15, and 16, are links connecting the rack 5 with the levers 9 and 14. 17, the upper or retaining rack. 18, a stud carrying the elbow-lever 19, which is provided with a handle. 20, another stud carrying the elbow-lever 21, which is connected by a link 22 with the lever 19. The rack 17 is carried on studs in the horizontal arm of the levers 19 and 21. 23, division-studs in the bar 24 of the traversing-frame.

The plate to be punched is put into a traversing-frame formed of two side-bars, 24 and 25, and two stretcher-bars secured by cottars to the side-bars, which are rabbeted to support the plate, and, when required, furnished with clamps to hold the plate down. 24 represents one of the sides of the traversing-frame, in which there is a groove to fit on the slide-bar U; into the outer side of the bar 24, is screwed a series of studs 23, represented in the engravings as being 12 inches from centre to centre apart from each other. The side 25 of the frame slides on the bars V, V. When the plates to be punched are very long, rollers may be used to carry the projecting ends of the traversing-frame. In fig. 9 is shown part of a frame, with a plate partly perforated. The racks 5, and 17, (fig. 10,) are drawn with three teeth in the length of a foot, which will divide plates to a four-inch pitch; but it will be obvious, that for a different pitch the racks must be changed; and it may, in some (cases such as when the pitch required is not an aliquot part of a foot) be necessary to alter the distance between the studs 23. Fig. 10 represents the traverse-apparatus, in the position it will be in when the retaining-rack is down, and the punches in the act of passing through the plate, and the traversing-rack having completed its return-stroke.

When the punches are being raised, the traversing-rack will rise also; and by the side-piece 26 (which is attached to it) acting against the roller 27, on a stud in the rack 17, will raise it also, and set the frame at liberty to be advanced by the cam *x*, through the mechanical means already described. In fig. 1, this traverse-apparatus is shown in the position it assumes when the plate is ad-

* In consequence of the elaborate character of the two engravings, we are obliged to postpone giving one of the plates until next month; but when the volume is bound up, the two plates will appear together.

vancing. The spiral-spring 28, acts on the lever 21, and forces the rack 17 down on to the pins 23. For every hole required to be punched in line with the width of the plate under operation, a corresponding hole must be made in a plate of the Jacquard, and an additional hole, marked 30, (see fig. 9), is also made, into which the stopping-bar 31 enters at every stroke until the punching be completed, at which time the Jacquard plate 32, which is left blank, will push all the selecting-bars *e* beyond the rams P, and at the same time, by pushing the bar 31, disengage the cam-shaft Q, by the mechanism to be hereafter explained, at the point where the punches and the levers *o*, are held up, and thus will allow the perforated plate to be taken out of the machine, and another plate to be put into it. The stopping-bar 31, is provided with a projection on its lower surface, which depresses the click-lever 39, when the bar is pushed back; the lever 33 is keyed on a shaft 34, moving in bearings at the back of the depressor; on the other end of the shaft 34, is keyed the lever 35, to the upper end of which is attached the link 36, connecting it with the elbow-lever 37; theend of the other arm of this lever is inclined, for the purpose of unlocking the plate R*, and is provided with a stud, on which is a latch 38, the tail of which comes in contact with the incline on the elbow-lever 37, when it is in the position shown in dotted lines in fig. 3; and as the wheel R revolves, the latch becomes disengaged from the opening between the two projections cast on the said wheel, at which time the cam-shaft Q, ceases to revolve. When the stopping-bar 31 has been pushed back, it depresses the lever 39, and liberates the lever 33 from behind the projection on the lever 39, when the spring 40 will pull the elbow-lever 37 into the position shown in dotted lines. To the blocks *h*, a small shaft is attached, on which are two levers, suspending by links a plate of metal similar to a blank card-plate, except that the holes for the guide-pins are cut at the bottom edge. At each end of the same shaft is a lever-handle, held up or down by a side-spring in the ordinary way. The use of this apparatus is as follows:—Should it be required to stop the machine before the plate is finished, by raising the lever here referred to, the blank plate will come in front of the roller, and will act the part of a blank Jacquard plate, and stop the machine.

Having now described the principal parts of the machine, we shall proceed to explain the manner of its working. The plate to be punched having been placed in the traversing-frame, on the sides U, and V, is then pushed forward. In its progress, the first pin of the series 23, passes under the inclined end of the rack 17, until the first notch in the rack falls upon the pin. The driving-strap being now on the fast pulley K, the machine is set to work by pulling down the handle 42, keyed on the shaft 34, until the lever 33 is latched by the click-lever 39; the elbow-lever 37 is then, by the spiral-spring 40, brought into the position shown in fig. 3. The latch 38 being now liberated, will, by the action of the spring 41, (see fig. 1,) drop into the notch in the wheel R, the first time it comes round; the cam-shaft Q will now revolve at the same speed as the shaft F, and the Jacquard-roller *f*, will be drawn back and made to perform one-sixth of a revolution on its centres; after which it will be advanced, and the first card of the series will remove those selecting-bars for which there are no holes in the Jacquard plate; the other selecting-bars will remain over their respective rams P, which will then force down the punches through the plate, by the descent of the depressor T. A little before the punches have gone through the plate under operation, the levers *o*, are made to press upon it, and are held there while the punches are being withdrawn by the bar *s*, which rises simultaneously with the depressor T, during one-half of its ascent.

Whilst the depressor is continuing its ascent and descent through the other half of the stroke, the roller *f* recedes, and draws with it the bar *m*, which brings all the selectors again over the punch-rams P. The roller *f*, while receding, having performed another sixth of a revolution, will, on advancing, bring another of the Jacquard plates against the selectors, and the operation will be repeated until all the holes are punched in the plate under operation.

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*Iron Vessels.*—Mr. Fowles of North Shields, suggests the following improvements in the construction of iron vessels, by forming the keel and kelson of plate or bar-iron in one or two breadths, from 1½ to 2½ inches in thickness, and from 20 to 24 inches deep, and then to form the floors of angle-iron in two lengths, and turn the ends of each up the side of the kelson, and connect them together by rivets through the kelson from side to side. The floor plates also to be in two lengths, which being rivetted to the floors, the two sides of the ship will be connected together.

## CANDIDUS'S NOTE-BOOK, FASCICULUS LXXXIV.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. In that very amusing, but slovenly and in parts rather dull congeries of gossip, entitled "Nollekens and his Times," *Museum* Smith speaks of a certain "*happy possessor* of some of the *worst fragments of the antique in this kingdom*, who employs a mere mason to put them together, and is perfectly satisfied though a right foot has been most ingeniously placed upon a left leg!" Who the "happy possessor" alluded to was, I know not, but I do know that, *mutatis mutandis*, the satire applies as forcibly, or in general far more forcibly, to the stupid, and tasteless, and bungling, botchings-up of architectural odds and ends—whether antique or mediæval, classical or ecclesiastical—into a design intended to pass as an unexceptionable specimen of the particular style which is professedly imitated, but generally caricatured more or less when so treated,—*secundum artem*, but contrary to all artistic principle, and not unfrequently contrary to meaning and purpose also. Would that in architecture no greater blunders were ever committed than that of sticking "a right foot on a left leg,"—in which case the *artist* might fairly have excused himself by swearing point blank that it was not the *right* foot.—Our being imitators at the present day might be forgiven; but we are not so much imitators, as mere *copyists*, incapable of entering into the spirit or meaning of our models,—which are to us little better than blind guides, simply because we ourselves follow them blindly, and without the least regard to widely-altered circumstances. What more may, under present circumstances, be made of a style, is what we never consider. Yet if we really studied our models, we should find—at least, in all those most deserving of being studied—every part well *motived* and adapted to the express occasion. How far we in that respect imitate those who have gone before us, I leave it to the impartial reader to determine for himself.

II. In his above-mentioned book, Smith is pleased to say: "Men of true taste visit a mansion only upon the report of its statues, busts, and pictures. The architecture of a house unadorned by such productions of art, would not induce the general traveller to drive twenty miles out of his road, nor even five. How few allurements, indeed, would the Marquis of Lansdown's, Lord Pembroke's, Lord Egremont's, Lord Farnborough's, Sir Abraham Hume's, Mr. Peel's, (now Sir Robert), and many other noble mansions have, if totally destitute of their fine collections of statues and pictures!"—No doubt such would be the case, but why?—first, because there is nothing whatever of architectural interest in the "noble mansions" themselves; and, secondly, because if there were, your "general travellers" have very little, if any taste at all for architecture. I was the other day in a house here in town,—one that I may fairly call an "architectural house," which although totally "destitute of pictures and statues," with the exception of a *basso-relievo* by Lough, over a chimney-piece in one of the rooms, is in itself all *picture*—as superior to Peel's as a pine-apple is to a pippin. For my own part, whenever I go over a house for the first time, I have neither eyes nor thought—nor if I had, I have not time—for anything but the architecture itself. As to pictures and statues, any dowdy house may be bedizened out with them, and still be, as a house, as dowdy as ever,—a perfect cluster of C's: very convenient, very comfortable, very commodious, very correct, very *comme-il-faut*, and very (most of all) common-place.

III. In his anecdotes relative to Cosway, Nollekens' biographer says that, after quitting Pall-Mall, "he (Cosway) fitted up his new residence (No. 20, Stratford-place) in so picturesque, and indeed so princely a style, that I regret drawings were not made of the general appearance of each apartment; for many of the rooms were more like scenes of enchantment pencilled by a poet's fancy than any thing, perhaps, before displayed in a domestic habitation." If such really was the case, they certainly were worthy of being delineated; yet we may be allowed to entertain some misgivings—first, because such a character of the house partakes too much of the "*glamour* might" of some of George Robins's advertisements; and, secondly, nothing is said to corroborate it, or to give us any idea whatever of those "scenes of enchantment," notwithstanding that the writer could at least have done that,—have spoken of "the general appearance of each apartment," and have so far rescued them from complete oblivion. Instead of which, he merely goes on to astound us by enumerating some of the costly articles of furniture and *vertû*

which were displayed in the habitation of that once fashionable and now forgotten painter:—to wit, "ancient chairs, couches, and conversation stools, elaborately carved and gilt, and covered with the most costly Genoa velvets; escritoires of ebony inlaid with mother-of-pearl; rich caskets for antique gems exquisitely enamelled, and adorned with onyxes, opals, rubies, and emeralds (!). There were also cabinets of ivory, curiously wrought; mosaic tables set with jasper, blood-stone, and lapis-lazuli." Suffice it to say, that there were besides, among a variety of other things, "massive musical clocks, ottomans superbly damasked, Persian carpets, chimney-pieces carved by Banks, bronzes, models in wax and terracotta, crystal cups adorned with the York and Lancaster roses, &c. &c." To meet with such prodigal sumptuousness in the house of a painter must have been astonishing enough—almost incredible when contrasted with the scrubby, though never scrubbed, dog-hole rooms in which old "Nolly" and his amiable spouse *thrived* so well; or the wretched, but richly cobwebbed, garret in which Barry entertained Burke with a beef-steak and a pot of porter.—Still, I am quite at a loss to make out, from all that Smith says of Cosway's house, aught that warrants the expression of the rooms being so many *scenes* of enchantment, there being not a syllable even with regard to any of their decorations, or to indicate any particular fancy, or *recherché* taste, or well-studied effects in the rooms themselves. Sumptuous furniture and almost priceless works of art may be put into a very common-place room; but in such case, the latter is merely the receptacle of the other objects,—stripped of which, it would not be worth looking at; whereas—in a first-rate mansion, at least—every part of it, except the entirely private and domestic rooms, should be laid out with studied regard to effect, and to variety of effects—without, however, departing from consistency as to general character. Each apartment should be itself a picture,—strikingly beautiful in itself, charming, captivating, before it receives its finishing touches in the way of furniture and other accessories. At present, as they are left by architects, rooms (even those in the best houses) are little better than blanks,—large four-sided boxes for the cabinet-maker and upholsterer to fill; in doing which, they may chance to empty your purse before you are aware of it,—or if they do not actually do that, they are likely to disgrace your taste by cramming your rooms with a medley of ill-assorted articles, agreeing only in being all alike very expensive ones.

IV. In anecdotizing some of the former residents in St. Martin's-lane, Smith notices No. 60, as the house once occupied by Chippendale, "the most famous upholsterer and cabinet-maker of his day, to whose folio work on household furniture the trade formerly made constant reference. It contains, in many instances, specimens of the style of furniture so much in vogue in France in the reign of Louis XIV, but which, for many years past, has been discontinued in England. However,"—I entreat my reader to mark this—"as most fashions come round again, I should not wonder, notwithstanding the beautifully classic change brought in by Thomas Hope, Esq., if we were to see the unmeaning scroll and shell-work with which the furniture of Louis' reign was so profusely encumbered, revive; when Chippendale's book will again be sought after with redoubled avidity, and as many of the copies must have been sold as *waste-paper*, the few remaining will probably bear a high price." Smith's apprehension is already to a considerable extent verified; and that same Louis Quatorze taste, which, although dignified by such title, is essentially both puerile and barbarous, corrupt and *unprincipled*—quite contrary to every sound principle of sound art, seems to be now spreading through all branches of decorative design and ornamental manufactures; some recent specimens of which, though cried up by those who professing to guide public taste ought to know better, are chiefly remarkable not for elegance or beauty of form and combination in any respect, but rather for quite the reverse, and for what has been quaintly termed "*the depravity of elegance;*" which singular perversity of taste is the more unaccountable, as well as lamentable, now that we have Government Schools of Design. Really, if such institutions produce no better fruits than the specimens alluded to, the sooner they are broken up altogether, the better. The instruction there given, no more qualifies for producing artistic design, than learning to read and write qualify for a literary career. Were things left to take their natural and healthy course, very few except those who really possessed talent—or what is next to it, a decided relish for art—would think of applying to it. Where talent really exists, such institutions are no doubt highly beneficial, by enabling it to develope itself; but then, on the other hand, they are mischievous, inasmuch as they turn out upon the world a great many more who are quite talentless, though furnished with a certain degree of manual proficiency; and as such talentless creatures "must live," and cannot possibly be interdicted from exercising *pro malo publico* what they are pleased to call their "talent," the ultimate injury to art and to public taste is greater than the benefit. I remember a priggish young Oxford student boasting in company of the many eminent men who had been educated in *his* college, when he was cut short by some one calling out to him—"But you don't say a word of the thousands and tens of thousands of blockheads which it has also turned out," adding, *sotto voce*, "and I take you to be one of them."

V. In a letter on the subject of the the Architectural Publication Society, a correspondent of the *Athenæum* says, after quoting what is stated in that Society's prospectus, as to the paucity of architectural works in this country: "Surely the thumb-screw must have been applied to extort this confession!" When a remark to the same effect—that is, animadverting upon the paucity of English architectural publications, was made some short time ago in the *Westminster Review*, a gentleman who now figures among the "Promoters" of the above-mentioned Society, thought proper to contradict it publicly at one of the meetings of the Institute; nevertheless, what was then deemed an injurious calumny, is now proclaimed to be the fact. Indeed, it is wonderful that any one should have had sufficient hardihood to dispute it. For a certain class of architectural books, there has been a considerable demand and corresponding degree of supply, of late years; but they are merely elementary ones, and besides, almost exclusively confined to the Gothic style and to ecclesiastical architecture. Even graphic publications, such as those by Haghe, J. Nash, Richardson, and others, have been entirely mediæval—at least, of the "olden times" in subjects, and some of them altogether continental in their subjects also. We possess no satisfactory illustrations of contemporary English buildings, either in collections containing examples by different architects, or in works brought out by the respective architects themselves. Sir Jeffrey Wyatville's "Windsor Castle," is the last and almost the only English publication of the kind that has appeared in the present century; and that was by no means so satisfactory and interesting as it might have been, it doing only half its work, owing to the entire omission of sections, notwithstanding that they were indispensably requisite for much important information that is not to be obtained at all, except by means of such drawings. To whatever it may be ascribed, this falling-off in architectural publications is all the more surprising, when we consider how very much has been done in architecture during the last thirty years. Some few years ago, Mr. Weale, as will very well be recollected, made an offer to the Institute to bring out annually a volume of designs of the best buildings executed by living architects; but instead of such liberal offer being thankfully accepted, it was rejected not only once, but twice—for some time after the first rejection, it was repeated, and rejected moreover in the most sulky and ungracious manner. Yet now, these same people—for many, if not most of the "Promoters" belong to the Institute—come forward and whine out, that in architectural publications we are far behind all our continental neighbours, and "our deficiencies are very great, as a comparison of catalogues will show"! It would seem, then, that something like shame is at length felt. Let it be disguised as it may, the fact is, architectural works of a higher class (consequently expensive ones), similar to those which have appeared on the continent during the last thirty or forty years, are not saleable—that is, do not obtain a remunerating sale. There is no encouragement for bringing them out; wherefore, all enterprise of the kind is checked by certainty of loss. There are no publishers of them, for a plain and unanswerable reason—viz., there are no purchasers of them. It is not indeed to be supposed, that every copy would remain unsold, but the purchasers are so exceedingly few, that works of the kind could not be provided for them, except by putting an enormous price upon the books. Why all this should be the case, it is more easy to guess than it would be flattering to say. According to all appearances, the demand for them ought to be far greater than ever. The architectural profession has surprisingly increased in numbers; then we have a Royal and chartered Institute, which of course exerts itself most laudably in promoting and diffusing on all sides a taste for architectural studies; then, again, we have a Fine Art Commission, under whose cognizance architecture comes very prominently forward——pity, let me observe, *par parenthèse*, that said Commission did not take under their cognizance also Mr. Blore's additions to Buckingham Palace!——and as the Commissioners are selected from the aristocratic classes, the very natural presumption is, that Architecture, as well as the other Fine Arts, is studied among our aristocracy and the higher ranks of society. We have *blue-books* on matters of art, architecture included; *item*, architec-

tural societies almost innumerable;—nevertheless and notwithstanding all these favourable symptoms, architectural study—at any rate, architectural publishing, is now at the lowest ebb. Yet, hardly is it because we in this country are so poor that we cannot afford to indulge in those book-luxuries, which our certainly not wealthier continental neighbours do. The plain truth is, that notwithstanding all our present chattering about art, we know nothing about it, and care less:—now, if any one calls that a *bull*, I return the compliment, by calling him a great *calf*.

VI. If architectural works, corresponding in character with those which used at one time to be published in this country, and which up to the present time have continued to be brought out upon the continent, are no longer engaged in by us, it is to be attributed, some will perhaps say, to their being supplied to us by the continent itself. That such publications as those of Schinkel, Kleuze, Gärtner, Famin, Gauthier, Letarouilly, Cicognara, Canina, Cassina, Diedo, Runge, Gladbach, Tietz, Joly (Chambre des Deputés), Calliat, (Hotel de Ville de Paris), and a great many others, are known here, there can be no doubt. One or two of them are stock-books with English booksellers. Yet, whether they have been imported to such extent as to render all home-production of the same sort quite unnecessary, may very well be doubted. Granting, however, such to be the fact, the consequence is, the continent gets nothing of a similar kind from us in return; wherefore, foreign architects, who would probably be benefitted by some exchange of ideas with us, are left to suppose that English ones produce nothing worthy of being shown, or that will bear the test of examination when fully exposed by being delineated in all its parts. We can very well afford, it may be said, to let other countries entertain whatever opinions they please of us, in the matter of architecture and art. Very true; why, then, are some among us so sore, so piqued, and so touchy, whenever it happens to be intimated that we lag far behind foreigners in regard to architectural publishing, "as any comparison of catalogues will show"—a confession now paraded before the public with the consent and under the auspices of several of our leading architects? If we have acted right of late years in entirely abstaining from producing architectural publications that might proudly rank with the best foreign ones of the kind, there is nothing at all to be angry or to blush at, whenever as much is stated. Rather ought we to congratulate ourselves upon our superior prudence and discretion. Why should "any comparison of catalogues" disturb us, or discompose the serenity of our tempers? On the other hand, if it be now considered desirable to show rivalry with the continent, in respect of architectural publications, what is contemplated by the "Architectural Publication Society" will go but a very little way indeed towards accomplishing such object.

VII. It might very naturally be imagined that architecture is pretty generally studied by our higher and middling classes, and that there would accordingly be a considerable and constant demand for books relating to it, it being from those classes that those who sit in committee and in judgment upon designs sent in at competitions are selected, or else elect themselves. They are of course all "highly respectable" and "honourable" persons, and so forth; yet that avails nothing, if they possess not at the same time some intelligence of architecture itself, which certainly does not come all at once by intuition, just when there happens to be occasion for exercising it, nor is it to be acquired without considerable study and application. Possibly, it may be that those who enter committees of the kind are so exceedingly ignorant, as not to be at all aware of the responsibility they take upon themselves, or their own utter unfitness for the office they assume. The consequence is, that although by undertaking it they are dignified—at least, fancy themselves to be so—art is damned. According to the present precious system of managing such matters, the sending in a carefully-studied design is no better than casting pearls before swine. A production of the kind elicits nothing better than a grunt, and the decision is made in favour of swill and Sansovino. Now, if gentlemen like to call for a bottle of genuine old Sansovino, they are welcome to do so; but it is, as my Lord Liverpool would have said, "really too bad" to cause other people to send in a hundred samples of various sorts, when the said Sansovino alone was wanted. Alas! for both the *nous* and the honour of the Army and Navy,—at least, for those of the Army and Navy Club, who, after taxing in no ordinary degree (owing to the limited space of the first sight) the ingenuity of between sixty and seventy architects, decided in favour of a prosaic affair vamped-up after Sansovino. That busy-body prig, Count d'Orsay, deserves to be well ducked in a 'Orse-pond, for leading the Army and Navy—our British Army and Navy, or their Club at least—by the nose. Rather ought the "club" to have been so wielded as to knock his Countship down, and send him to grope in the abyss of his coxcombical conceit. However, if English architects like to be kicked by French counts, without attempting to resent it, so be it. They may be both kicked and spit upon for aught that I care, if they are too cowardly to protect themselves.

VIII. In what he says of the Royal Exchange, the writer in the current number of the "*Westminster*" makes no objection to that edifice being so greatly disfigured by the shops. It is also somewhat strange, that while he so vehemently condemns the excess to which decoration has been carried at the Houses of Parliament, he is quite silent with regard to what persons less critical will be likely to consider the greatest fault of all—namely, the enormous cost so incurred. Mr. Hume's words, when he said (in 1836) he firmly believed that the expense of Mr. Barry's plan would be double the estimate, have already been verified. Mr. Mackinnon went even further, and declared that "Two Millions will not cover the expense." Let us then "firmly believe" that Three Millions will do so.

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## ARCHITECTURE AT THE ROYAL ACADEMY.

[THIRD NOTICE.]

Owing to the Exhibition's terminating this season somewhat earlier than usual, and to our not knowing that it was about to close until just a day or two before, when we were prevented from re-visiting it, we must now trust to our memory and a few slight notes previously taken down by us, for such further account as our readers must now be content with. Of the one hundred and sixty drawings in the Architectural Room, forty-six may very well be said to have "no business" there, they being not original architectural productions—not designs and compositions by the respective exhibitors, but merely views and other portraitures of different buildings, or bits of buildings. Now, in our opinion, subjects of that kind are at the best somewhat out of place in an architectural exhibition, if only because an annual exhibition is, unless otherwise expressed, expected to show us the performances of contemporary talent. Were the Architectural Room three or four times larger than it is,—or, what would be better still, were there two sufficiently spacious rooms, one of which might be set apart for what is mere architectural portraiture, there would be no objection to productions of the latter description being admitted, provided they were worthy of being so, either on account of intrinsic interest or freshness of subject, or superior ability and charm as regards artistic execution. Unfortunately, the reverse of this is the case: buildings that have become quite hackney and stale (having been shown again and again both in book-engravings and drawings, and also in copies from them, till we almost sicken at the bare mention of their names) are allowed to find admission at the Academy, in hundreth-edition representations of them. And not only are such things admitted, while original architectural productions are turned away, but many of them—and perhaps some of the stalest or else most trivial in subject, are allowed to occupy better places than drawings which show us, or rather would show us what we have not before seen, were they not hung where they cannot be seen themselves. As we have already observed, this is the unhappy case of No. 1095, the new Coffee Room of the Carlton Club-house; while, as if on purpose to render that case a still more scandalous one several large frames, which contain only very uninteresting views of architectural ruins, are placed very conspicuously nearly upon the "*line*." Had No. 1095 been differently described—had it passed, as it very fairly might have done, under the name of Mr Sydney Smirke, with the information that the encaustic embellishments were by Mr. Sang, it would, we suspect, have been very differently treated. Well, let us hope that it will be admitted again next season, for it certainly cannot be rejected as having been "already publicly exhibited," unless being publicly put out of sight is just the same as being "publicly exhibited." The *hangers* seem to think that they are at liberty to do just as they please in the Architectural Room, and commit all sorts of absurdities there without incurring the slightest censure. They know well enough that the architectural drawings are never spoken of by the newspapers press; the *hangmen*, however, are merely the executioners: they are not responsible for judicial blunders and want of judgment in the *judges* themselves, who not content with condemning this year many meritorious architectural performances, by rejecting them, have, by admitting them signified their approbation of a great many others which, whatever some among them may be as drawings, are below mediocrity as designs. If it be the policy of the Academy to bring architecture—that is,

architectural drawings, into still further discredit and disfavour with the public, as a step towards such works being excluded altogether, after its being voted to be beneath the *dignity* of a Royal Academy to admit them into its exhibitions, much as we may admire the astuteness of such policy, we must reprobate its treacherousness.

To begin—as it is now high time for us to do, our notices of such drawings as we can now speak to, we will first of all mention those which belong to what is invariably the most scanty, though assuredly not the least interesting or least important class of subjects, we mean Interiors. One of them, whose title excites curiosity the most, is, as has already been stated, put quite out of sight. The next, No. 1117, "The Drawing Room and Corridor of the Army and Navy Club-house," *Messrs. Allom and Cross*, fares very little better, it consisting of two small drawings in the same frame, which being only slightly tinted in sepia, and hung up considerably above the eye, are hardly observable.* Of these two subjects we prefer the "Corridor" one, as manifesting, besides taste and considerable novelty also, more judgment with regard to due gradation of effect than the usual mistakenly ambitious practice of making the approach to the apartments in a club-house or private mansion far more impressive and important—architecturally speaking—than the rooms themselves,—pompous prefaces to what is, if not actually paltry, more or less common-place. We question whether the actual Club-house now in progress will be able to show anything half so full of effect—so scenic, yet not at all extravagantly or forcedly so, but rather quite the reverse—as this portion of Messrs. A. and C.'s design would have been. At the same time, we think there was more than one other design offered that was upon the whole still better than theirs. However, the Club, or perhaps the Count—the Hercules who wields that *club*, and against whom all the arguments of criticism *count* for nothing, has decided differently. We find that we have passed over in its numerical order, an interior placed conspicuously enough, therefore not at all likely to be passed by unnoticed on the wall, viz., No. 104, "Design for the Interior of a Room, decorated with Illustrations of the Coldstream Guards," *H. Shaw*. This design is about as odd as its title is oddly worded. The drawing is a large and pains-takingly laboured one; the "interior" of the room shows what is meant for florid Tudor Gothic in all its floridness, in which flags and heraldic embellishments bear a prominent part; still it is not by any means to our taste, and we therefore consign it over to the "illustrated" if not illustrious Coldstream Guards, for their especial admiration. As No. 1299, "Drawing of an Ancient State Pall belonging to the Company of Fishmongers," is by the same exhibitor, it may properly enough come in for notice immediately after the preceding. Its title shows it to be an exceedingly antiquarian affair—far more antiquarian than at all architectural. It is, in fact, little more than a highly-laboured drawing of a more curious than tasteful needle-work relic. What business it has to be here in one of the very best situations, we do not understand; on the contrary, marvel much at finding it here at all, knowing, as we happen to do, some of the architectual *designs* which were turned away in order to make way for such a very *old-ladyish* affair as this. Perhaps it took the fancy of the old ladies in the Academy.

No. 1200, "Entrance Hall and Staircase of the British Museum," as decorated by *L. W. Collman*, is a large and most captivating drawing, and strange perhaps to say tolerably well-placed. As to its subject, it is not so acceptable as one less known would have been, the Museum being freely open to every one; and so far, we could wish that Mr. C.'s drawing had changed places with Mr. Sang's,—the interiors of club-houses being not made of "penetrable stuff," but their beauties as carefully secluded from gaze profane and critic's eye, as are those of an eastern harem. In itself, the Museum staircase is not particularly striking—striking only by comparison with the plainness and bareness of the other parts of the building—the King's Library alone excepted. Faithful, too, as is Mr. C.'s representation, it is a flattering one, because of the hall itself it shows nothing more than what serves as fore-ground to the staircase, which is seen directly in front. All disturbing circumstances—all that detracts from or interferes with the scenic effect, as the staircase is thus shown, is kept out of sight. You are at liberty to fancy that it displays itself thus on first entering, or that if not at one extremity of the hall, it comes in at least at the centre of one side of it.—No. 1224 gives another staircase—viz., that at "Beaumanor Park, Leicestershire," *W. Railton*; in favour of which very little can be said, either as regards the design itself, or the manner in which the view is taken. The style adopted is the heavy, cumbrous Elizabethan, whose quaint carved-work is far more costly than elegant, although it costs an architect nothing—no study or thought, if he be content merely to copy without studying how to refine upon such style, and bring it into keeping with modern taste and notions as displayed in all respects throughout a modern residence.—No. 1288, "Design for an Entrance Saloon, adapted to the English climate," *W. Papworth*, puzzles us exceedingly. In what particular respect it is more adapted to our climate than any other room, we are unable to guess; unless it be that its excessive gaudiness and flutter of colours is intended to counteract the chilling influence of an English sky. Nor is the architecture at all better than the taste shown in embellishment as regards colour. The room has the look of a tawdry tavern "saloon."

We have got to the end of "Interiors," for we do not comprehend under that designation those of churches, both old and new; the former of which are of course mere views, not the designs of those who here exhibit them; while the latter, which might else be made to afford some exercise for inventive power and imagination, are, thanks to our modern ecclesiologists, their pedantry and their prudery, strictly bound to imitate, and as far as possible facsimilize, the old ones;—wherefore, to ecclesiologists and to Mr. Urban, we leave them. The only design of that class which struck us at the time, or which we can now call to mind with any distinctness, is 1183, "Highbury New Church, now erecting" by *T. Allom*. That this is a very charming drawing—one distinguished by its artistic treatment, we hardly need say, its author's name being a sufficient guarantee for such merit; but it has also great merit in other respects. The architecture itself is treated artistically;—all the spirit and better qualities of the style—Gothic or mediæval, as now matter of course, are preserved. The view here given of the church is, however, so exceedingly picturesque and *episodical*, that we cannot judge from it what the structure is or will be, upon the whole. Having mentioned this subject, we may be allowed to turn at once to another and quite different one, by the same architect—viz., No. 1229: "Continuation of a Design for Improving the Property on the Banks of the Thames, &c." This we take to be altogether "a castle in the air"—too gigantic a scheme; not, indeed, an impracticable one, but one which has not the slightest chance of being realised, or even seriously thought of at all in our time, or Mr. Allom's. When he conceived it and was at work upon his drawing, Louis Philippe was upon his throne: that Louis is so no longer; neither is Ludwig. *Tempora mutantur;* all Europe has received a shock—but we are getting prosy. To speak more architecturally and critically, we may observe, that for "improving property on the banks of the Thames," we should read "on the *north bank* of the Thames," because, like every other which has had a similar object in view, Mr. Allom's scheme provides no improvement whatever for the south or opposite bank of the river, the meanness and deformities of whose buildings would become more offensive than ever, were they to be confronted by, and looked at from terraces and quays on the north side, flanked by such façades as are represented in this design.

There is more than one good drawing and very fair design for houses in the Elizabethan style—shall we ever get to a Victorian style?—which we are unable now to particularise, but among which, if our memory deceives us not, as for reason explained it may do—is No. 1115, "A House now erecting at Southend, Sydenham," *H. E. Cox* and *E. Goodwin*. There is another drawing apparently by the same hand, but of a design by a different exhibitor, though in the same style, and similar also in many other respects; yet which it is we cannot undertake to say, the pencil notes in our marked catalogue being nearly effaced. To confess the truth we must now hurry on to *Finis*, and content ourselves with merely naming some of the few things that deserve to be rescued from the imputation of dulness and mediocrity, or even worse, with which the architectural part of this year's Exhibition is chargeable.—No. 1112, "The Stoke Station, now erecting from the designs, and under the superintendence of H. A. Hunt," *G. Buckler*, has considerable merit in parts, but is very unequal, and therefore unsatisfactory as a whole. Here again the style is Elizabethan; and did the drawing represent a *bonâ fide* production and monument of that age, it would be interesting enough; but as a design at the present day, it partakes too strongly of the fidelity of the Chinese tailor who copied all the holes in the coat which was sent to him as a pattern of an English one. Considerable praise is due to No. 1211, "Court-yard of a Gentleman's Farm-house, lately erected;" and No. 1213, "Design for a Chapel at Edmonton," both by *F. W. Ordish;* also to No. 1270, "Additions to Frankleigh House, Wilts," *H. Clutton*. Although there is too much of the aforesaid Chinese tailor in it, we confess to relishing Mr. Harkwick's design for a "House about to be erected at Aldermaston, Berks," No. 1217. Pity that it is of the "olden time" and not of our own; for if we

* Although the Exhibition is closed, we speak as usual in the present tense.